

CANNONDESIGN

Webster University
Interdisciplinary Science Building
St. Louis, Missouri

PROJECT MANUAL

Volume 2
Division 21-32

Dec 27, 2017

Conformed Set

SECTION 000110 - TABLE OF CONTENTS

PROCUREMENT AND CONTRACTING REQUIREMENTS GROUP

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
000110	Table of Contents	Cannon	X	X	X
003132.1	Subsurface Drilling and Sampling Report	Cannon	X		
003132.2	Soils Report	Akins	X		
007113	General Conditions of the Contract for Construction	Cannon	X		
007300	Supplementary Conditions	Cannon	X		

SPECIFICATIONS GROUP

General Requirements Subgroup

DIVISION 01 – GENERAL REQUIREMENTS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
012200	Unit Prices	Cannon	X		
012900	Payment Procedures	Cannon	X		
013100	Project Management and Coordination	Cannon	X		
013100.1	RFI Form	Cannon	X		
013200	Construction Progress Documentation	Cannon	X		
013233	Photographic Documentation	Cannon	X		
013300	Submittal Procedures	Cannon	X		
013300.1	Submittal ID Sheet	Cannon	X		
013300.2	Contractor's Certification Letter	Cannon	X		
014000	Quality Requirements	Cannon	X		
014200	References	Cannon	X		
015000	Temporary Facilities and Controls	Cannon	X		
015639	Temporary Tree and Plant Protection	SWT	X		X
016000	Product Requirements	Cannon	X		
016000.0	Substitution Request Form	Cannon	X		
017300	Execution	Cannon	X		
017329	Cutting and Patching	Cannon	X		
017419	Construction Waste Management and Disposal	Cannon	X		
017419.1	Form CWM-1	Cannon	X		
017419.3	Form CWM-3	Cannon	X		
017419.5	Form CWM-5	Cannon	X		
017419.7	Form CWM-7	Cannon	X		
017700	Closeout Procedures	Cannon	X		
017823	Operation and Maintenance Data	Cannon	X		
017839	Project Record Documents	Cannon	X		
017900	Demonstration and Training	Cannon	X		

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

018113.13	Sustainable Design Requirements – LEED 2009-New Construction and Major Renovations	Cannon	X		
019113	General Commissioning Requirements	R&B		X	

Facility Construction Subgroup

DIVISION 02 – EXISTING CONDITIONS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
024119	Selective Structure Demolition	Cannon	X		

DIVISION 03 – CONCRETE

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
033000	Cast In Place Concrete	DMA	X		
033500	Concrete Finishing	Cannon			X

DIVISION 04 – MASONRY

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
042000	Unit Masonry	Cannon	X		X
044300	Anchored Stone Masonry Veneer	Cannon	X		

DIVISION 05 – METALS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
051200	Structural Steel Framing	DMA	X		
053100	Steel Decking	DMA	X		
054000	Cold Formed Metal Framing	Cannon	X		
054523	Laboratory Metal Supports	Cannon			X
055000	Metal Fabrications	Cannon	X		
055113	Metal Pan Stairs	Cannon			X
055213	Pipe and Tube Railings	Cannon			X
057100	Decorative Metal Stairs	Cannon			X
057300	Decorative Metal Railings	Cannon	X		
057313	Glazed Decorative Metal Railings	Cannon			X
057500	Decorative Formed Metal	Cannon			X

DIVISION 06 – WOOD, PLASTICS, AND COMPOSITES

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
061053	Miscellaneous Rough Carpentry	Cannon			X
061600	Sheathing	Cannon	X		

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

064113	Wood-Venner-Faced Architectural Cabinets	Cannon			X
064116	Plastic-Laminate-Faced Architectural Cabinets	Cannon			X
064216	Flush Wood Paneling	Cannon			X
064600	Wood Trim	Cannon			X
066400	Plastic Paneling	Cannon			X

DIVISION 07 – THERMAL AND MOISTURE PROTECTION

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
071113	Bituminous Damproofing	Cannon	X		
071326	Self-Adhering Sheet Waterproofing	Cannon	X		
071413	Hot Fluid-Applied Rubberized Asphalt Waterproofing	Cannon	X		
072100	Thermal Insulation	Cannon	X		
072600	Under Slab Vapor Barrier	Cannon	X		
072726	Fluid Applied Membrane Air Barriers	Cannon	X		
074243	Metal Composite Material Wall Panels	Cannon	X		
074646	Fiber-Cement Siding	Cannon	X		
074800	Cladding Support Systems	Cannon	X		
075323	Ethylene-Propylene-Diene-Monomer (EPDM) Roofing	Cannon	X		
076200	Sheet Metal Flashing and Trim	Cannon	X		
077100	Roof Specialties	Cannon	X		
077200	Roof Accessories	Cannon	X		
078100	Applied Fireproofing	Cannon			X
078413	Penetration Firestopping	Cannon			X
078446	Fire-Resistive Joint Systems	Cannon			X
079100	Preformed Joint Seals	Cannon			X
079200	Joint Sealants	Cannon			X
079500	Expansion Control	Cannon			X

DIVISION 08 - OPENINGS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
081113	Hollow Metal Doors and Frames	Cannon			X
081216	Aluminum Frames	Cannon			X
081416	Flush Wood Doors	Cannon			X
083113	Access Doors and Frames	Cannon			X
083333	Side Coiling Doors	Cannon			X
084123	Fire Rated Glass and Framing Systems	Cannon			X
084423	Structural-Sealant-Glazed Curtain Walls	Cannon	X		
087100.01	Storefront Door Hardware	Cannon	X		
087100.03	Door Hardware	Cannon			X
088000	Glazing	Cannon	X		X
088300	Mirrors	Cannon			X
089119	Fixed Louvers	Cannon	X		

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

DIVISION 09 - FINISHES

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
090500	Floor Preparation	Cannon			X
092116	Gypsum Board Shaft Wall Assemblies	Cannon			X
092216	Non-Structural Metal Framing	Cannon			X
092713	Glass-Fiber-Reinforced Plaster Fabrications	Cannon			X
092900	Gypsum Board	Cannon			X
093013	Ceramic Tiling	Cannon			X
095113	Acoustical Panel Ceilings	Cannon			X
095426	Linear Wood Ceilings	Cannon			X
096229	Cork Flooring	Cannon			X
096400	Wood Flooring	Cannon			X
096513	Resilient Base and Accessories	Cannon			X
096516	Resilient Sheet Flooring	Cannon			X
096519	Resilient Tile Flooring	Cannon			X
096623	Resinous Matrix Terrazzo Flooring	Cannon			X
096723	Resinous Flooring	Cannon			X
096813	Tile Carpeting	Cannon			X
096816	Sheet Carpeting	Cannon			X
097200	Wall Coverings	Cannon			X
097610	Concrete Sealer	Cannon			X
097713	Stretched-Fabric Wall Systems	Cannon			X
098310	Acoustical Plaster Surfacing	Cannon			X
098413	Fixed Sound-Absorbative Wood Panels	Cannon			X
098433	Sound-Absorbing Wall Units	Cannon			X
098453	Partition Closure	Cannon			X
099113	Exterior Painting	Cannon			X
099123	Interior Painting	Cannon			X
099230	Special Wall Coatings	Cannon			X
099714	Thermal-Break Coating for Steel	Cannon	X		
099737	Dry Erase Coatings	Cannon			X

DIVISION 10 - SPECIALTIES

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
101146	Visual Display Fabrics	Cannon			X
101400	Signage	KLI			X
102113.19	Plastic Toilet Compartments	Cannon			X
102800	Toilet, Bath and Laundry Accessories	Cannon			X
104313	Defibrillator Cabinets	Cannon			X
104413	Fire Protection Cabinets	Cannon			X
104416	Fire Extinguishers	Cannon			X
105210	Cylinder Bracket Support	Cannon			X

DIVISION 11 – EQUIPMENT

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
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**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

110140	Building Maintenance Equipment	Cannon	X		
111319	Stationary Loading Dock Equipment	Cannon	X		
113100	Residential Appliances	Cannon			X
114000	Foodservice Equipment	FFC		X	
115213	Projection Screens	Cannon			X
115300	Laboratory Equipment	Cannon			X
115313	Laboratory Fume Hoods	Cannon			X

DIVISION 12 – FURNISHINGS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
122200	Curtains and Drapes	Cannon			X
122413	Roller Window Shades	Cannon			X
123553	Laboratory Casework	Cannon			X
123623.13	Plastic Laminate Clad Countertops	Cannon			X
123661.16	Solid Surfacing Countertops	Cannon			X
123661.19	Quartz Agglomerate Countertops	Cannon			X
126100	Fixed Audience Seating	Cannon			X
129300	Site Furnishings	SWT			X

DIVISION 13 – SPECIAL CONSTRUCTION

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
130383	Controlled Temperature Rooms	Cannon			X

DIVISION 14 – CONVEYING EQUIPMENT

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
142100	Electric Traction Elevators	Cannon		X	X

DIVISION 21 – FIRE SUPPRESSION

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
210517	Sleeves and Sleeve Seals for Fire-Suppression Piping	Webb		X	
210518	Escutcheons for Fire-Suppression Piping	Webb		X	
210523	General-Duty Valves for Water-Based Fire-Suppression Piping	Webb		X	
210548	Vibration and Seismic Controls for Fire-Suppression Piping and Equipment	Webb		X	
210553	Identification for Fire-Suppression Piping and Equipment	Webb		X	
211119	Fire-Department Connections	Webb		X	
211200	Fire-Suppression Standpipes	Webb		X	
211313	Wet-Pipe Sprinkler System	Webb		X	
211316	Dry-Pipe Sprinkler System	Webb		X	

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

213113	Electric-Drive, Centrifugal Pumps	Webb		X	
213400	Pressure-Maintenance Pumps	Webb		X	
213900	Controllers for Fire-Pump Drivers	Webb		X	

DIVISION 22 – PLUMBING

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
220513	Common Motor Requirements for Plumbing Equipment	Webb		X	
220517	Sleeves and Sleeve Seals for Plumbing Piping	Webb		X	
220518	Escutcheons for Plumbing Piping	Webb		X	
220519	Meters and Gages for Plumbing Piping	Webb		X	
220523.12	Ball Valves for Plumbing Piping	Webb		X	
220523.14	Check Valves for Plumbing Piping	Webb		X	
220529	Hangers and Supports for Plumbing Piping and Equipment	Webb		X	
220548	Vibration and Seismic Controls for Plumbing Piping and Equipment	Webb		X	
220553	Identification for Plumbing Piping and Equipment	Webb		X	
220719	Plumbing Piping Insulation	Webb		X	
220800	Commissioning of Plumbing	R&B		X	
221113	Facility Water Distribution Piping	DMA		X	
221116	Domestic Water Piping	Webb		X	
221119	Domestic Water Piping Specialties	Webb		X	
221313	Facility Sanitary Sewers	DMA		X	
221316	Sanitary Waste and Vent Piping	Webb		X	
221319	Sanitary Waste Piping Specialties	Webb		X	
221323	Sanitary Waste Interceptors	Webb		X	
221413	Facility Storm Drainage Piping	DMA		X	
221423	Storm Drainage Piping Specialties	Webb		X	
221429	Sump Pumps	Webb		X	
223400	Fuel-Fire, Domestic-Water Heaters	Webb		X	
224213.13	Commercial Water Closets	Webb		X	
224213.16	Commercial Urinals	Webb		X	
224216.13	Commercial Lavatories	Webb		X	
224216.16	Commercial Sinks	Webb		X	
224500	Emergency Plumbing Fixtures	Webb		X	
224716	Pressure Water Coolers	Webb		X	
226113	Compressed-Air Piping for Laboratory and Healthcare Facilities	Webb		X	
226119	Compressed-Air Equipment for Laboratory and Healthcare Facilities	Webb		X	
226213	Vacuum Piping for Laboratory Facilities	Webb		X	
226219	Vacuum Equipment for Laboratory Facilities	Webb		X	
226313	Gas Piping for Laboratory Facilities	Webb		X	
226700	Processed Water Systems for Laboratory Facilities	Webb		X	

DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
230100	Basic Mechanical Requirements	Wm. Tao		X	
230500	Basic Mechanical Materials and Methods	Wm. Tao		X	
230600	Piping	Wm. Tao		X	
230800	Commissioning of HVAC	R&B		X	
231900	Mechanical Identification	Wm. Tao		X	
232400	Vibration and Seismic Control	Wm. Tao		X	
232500	Mechanical Insulation	Wm. Tao		X	
235000	HVAC Equipment	Wm. Tao		X	
238800	Air Distribution	Wm. Tao		X	
239500	Controls and Instrumentation	Wm. Tao		X	
239900	Testing, Adjusting and Balancing	Wm. Tao		X	

DIVISION 26 - ELECTRICAL

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
260000	Alternates	Wm. Tao		X	
260100	Basic Electrical Requirements	Wm. Tao		X	
260500	Basic Electrical Materials and Methods	Wm. Tao		X	
260800	Commissioning of Electrical Systems	R&B		X	
261100	Medium Voltage Cables	Wm. Tao		X	
261200	Conductors and Cables (to 600 Volts)	Wm. Tao		X	
261300	Raceways and Boxes	Wm. Tao		X	
261400	Wiring Devices	Wm. Tao		X	
261900	Electrical Equipment Supporting Devices	Wm. Tao		X	
261950	Electrical Identification	Wm. Tao		X	
262400	Vibration and Seismic Control	Wm. Tao		X	
264000	Distribution (to 600 Volts)	Wm. Tao		X	
264500	Grounding and Bonding	Wm. Tao		X	
265100	Indoor Lighting	Wm. Tao		X	
265200	Outdoor Lighting	Wm. Tao		X	
265700	Lighting Control Equipment	Wm. Tao		X	
266000	Special Systems	Wm. Tao		X	
266500	Standby Power Generation System (below 600 Volts)	Wm. Tao		X	
267100	Fire Alarm Systems	Wm. Tao		X	
268500	Electrical Heating	Wm. Tao		X	

DIVISION 27 – COMMUNICATIONS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
270100	Basic Communications Requirements	Faith		X	
270528	Pathways for Communications Systems	Faith		X	

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

270536	Cable Trays for Communications Systems	Faith		X	
270540	Communications Grounding and Bonding	Faith		X	
270800	Cable Testing and Administration	Faith		X	
271100	Communications Equipment Room Fittings	Faith		X	
271300	Backbone Cabling Requirements	Faith		X	
271500	Horizontal Cabling Requirements	Faith		X	

DIVISION 31 - EARTHWORK

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
311000	Site Clearing	DMA	X		
311500	Storm Water Pollution Prevention Plan	DMA	X		
312000	Earthwork	DMA	X		
312319	Dewatering	DMA	X		
315000	Excavation Support and Protection	DMA	X		
316329	Drilled Concrete Piers and Shafts	DMA	X		

DIVISION 32 – EXTERIOR IMPROVEMENTS

	Section Name	Author	Bid Package 1 12.03.15	Bid Package 2 03.01.16	Bid Package 3 03.15.16
321216	Asphalt Paving	DMA		X	
321313	Concrete Paving	DMA		X	
321373	Pavement Joint Sealants	DMA		X	
321400	Unit Paving	SWT			X
321443	Porous Unit Paving	SWT			X
328400	Planting Irrigation	SWT			X
329113	Soil Preparation	SWT			X
329200	Turf and Grasses	SWT			X
329300	Plants	SWT			X
329500	Vegetated Roof Assemblies	SWT			X

END OF TABLE OF CONTENTS

SECTION 210517 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems..
 - 3. Grout.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).

4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements..

2.3 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and larger; Galvanized-steel-pipe sleeves.
 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and larger; Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

- b. Piping NPS 6 and larger; Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
- 4. Concrete Slabs above Grade:
 - a. Piping NPS; 6; Galvanized-steel-pipe sleeves.
- 5. Interior Partitions:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and larger; Galvanized-steel-sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with rough-brass finish.
 - f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with rough-brass finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 210518

SECTION 210523 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Two-piece ball valves with indicators.
 - 2. Iron butterfly valves with indicators.
 - 3. Check valves..
 - 4. Iron OS&Y gate valves.
 - 5. Trim and drain valves.

1.3 DEFINITIONS

- A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- B. NRS: Nonrising stem.
- C. OS&Y: Outside screw and yoke.
- D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and weld ends.
 - 3. Set valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.
- D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
 1. Main Level: HAMV - Fire Main Equipment.
 - a. Level 1: HCBZ - Indicator Posts, Gate Valve.
 - b. Level 1: HLOT - Valves.
 - 1) Level 3: HLUG - Ball Valves, System Control.
 - 2) Level 3: HLXS - Butterfly Valves.
 - 3) Level 3: HMER - Check Valves.
 - 4) Level 3: HMRZ - Gate Valves.
 2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
 - a. Level 1: VQGU - Valves, Trim and Drain.
- B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
 1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves.
 - a) Single check valves.
 - 3) Miscellaneous valves.
- C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.
- D. ASME Compliance:
 1. ASME B16.1 for flanges on iron valves.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

2. ASME B1.20.1 for threads for threaded-end valves.
 3. ASME B31.9 for building services piping valves.
- E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- F. NFPA Compliance: Comply with NFPA 24 for valves.
- G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.
- H. Valve Sizes: Same as upstream piping unless otherwise indicated.
- I. Valve Actuator Types:
1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 2. Handwheel: For other than quarter-turn trim and drain valves.
 3. Handlever: For quarter-turn trim and drain valves **NPS 2 (DN 50)** and smaller.
- J. Valves to be rated for 175psi, where system pressures exceed this, provide 250psi rated valves.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. NIBCO INC.
 2. Tyco Fire & Building Products LP
 3. Victaulic Company.
- B. Description:
1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
 2. Minimum Pressure Rating: 175 psig.
 3. Body Design: Two piece.
 4. Body Material: Forged brass or bronze.
 5. Port Size: Full or standard.
 6. Seats: PTFE.
 7. Stem: Bronze or stainless steel.
 8. Ball: Chrome-plated brass.
 9. Actuator: Worm gear or traveling nut.
 10. Supervisory Switch: Internal or external.
 11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
 12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 IRON BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following;
1. Anvil International.
 2. Fivalco Inc.
 3. Globe Fire Sprinkler Corporation.
 4. Kennedy Valve Company; a division of McWane, Inc.
 5. NIBCO INC.
 6. Tyco Fire & Building Products LP.
 7. Victaulic Company.
- B. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
 2. Minimum Pressure Rating: 175 psig.
 3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
 4. Seat Material: EPDM.
 5. Stem: Stainless steel.
 6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
 7. Actuator: Worm gear or traveling nut.
 8. Supervisory Switch: Internal or external.
 9. Body Design: Lug or wafer or Grooved-end connections.

2.4 CHECK VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Anvil International.
 2. Fire Protection Products, Inc.
 3. Globe Fire Sprinkler Corporation.
 4. Kennedy Valve Company; a division of McWane, Inc.
 5. Mueller Co.
 6. NIBCO INC.
 7. Reliable Automatic Sprinkler Co., Inc. (The).
 8. Shurjoint Piping Products.
 9. Tyco Fire & Building Products LP.
 10. Venus Fire Protection Ltd.
 11. Victaulic Company.
 12. Viking Corporation.
 13. Watts; a Watts Water Technologies company.
- B. Description:
1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
 2. Minimum Pressure Rating: 175 psig.
 3. Type: Single swing check.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.5 IRON OS&Y GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Hammond Valve.
4. Kennedy Valve Company; a division of McWane, Inc.
5. Mueller Co.
6. NIBCO INC.
7. Victaulic Company.

- B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved or Threaded.

2.6 TRIM AND DRAIN VALVES

- A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Fire Protection Products, Inc.
 - c. Fire-End & Croker Corporation.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Potter Roemer LLC.
 - g. Red-White Valve Corporation.
 - h. Tyco Fire & Building Products LP.
 - i. Victaulic Company.
 - j. Watts; a Watts Water Technologies company.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

2. Description:

- a. Pressure Rating: 250 psig.
- b. Body Design: Two piece.
- c. Body Material: Forged brass or bronze.
- d. Port size: Full or standard.
- e. Seats: PTFE.
- f. Stem: Bronze or stainless steel.
- g. Ball: Chrome-plated brass.
- h. Actuator: Handlever.
- i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
- j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Fire Protection Products, Inc.
- b. NIBCO INC.
- c. United Brass Works, Inc.

2. Description:

- a. Pressure Rating: 250 psig.
- b. Body Material: Brass or bronze.
- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc: Bronze.
- f. Packing: Asbestos free.
- g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. NIBCO INC.
- b. United Brass Works, Inc.

2. Description:

- a. Pressure Rating: 250 psig.
- b. Body Material: Bronze with integral seat and screw-in bonnet.
- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc Holder and Nut: Bronze.
- f. Disc Seat: Nitrile.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

- A. Comply with requirements in the following Sections for specific valve installation requirements and applications:
 - 1. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
 - 2. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
 - 3. Section 211316 "Dry-Pipe Pre-Action Sprinkler System" for application of valves in dry-pipe pre-action sprinkler systems.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the pipe center.
- F. Install valves in position to allow full stem movement.
- G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
- I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 210523

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Elastomeric hangers
 - 2. Restraint channel bracings.
 - 3. Seismic-restraint accessories.
 - 4. Mechanical anchor bolts.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 - 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
1. Site Class as Defined in the IBC.
 2. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.
 3. NFPA 13

2.2 RESTRAINT CHANNEL BRACINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. Hilti, Inc.
 3. Mason Industries, Inc.
 4. Unistrut; Part of Atkore International.
- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 SEISMIC-RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. Kinetics Noise Control, Inc.
 3. Mason Industries, Inc.
 4. TOLCO.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.4 MECHANICAL ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Hilti, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
- B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete."
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Equipment Restraints:
 - 1. Install seismic snubbers on fire-suppression equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- D. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet
- E. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- 7. Measure isolator deflection.
- 8. Verify snubber minimum clearances.

- D. Remove and replace malfunctioning units and retest as specified above.

- E. Prepare test and inspection reports.

END OF SECTION 210548

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SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Valve tags.
 - 5. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.
- D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.
 - d. Champion America.
 - e. Craftmark Pipe Markers.
 - f. emedco.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Marking Services, Inc.
 - j. Seton Identification Products.
 - 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving,
 - 3. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 6. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Carlton Industries, LP.
 - 4. Champion America.
 - 5. Craftmark Pipe Markers.
 - 6. emedco.
 - 7. LEM Products Inc.
 - 8. Marking Services Inc.
 - 9. National Marker Company.
 - 10. Seton Identification Products.
 - 11. Stranco, Inc.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Pipe Markers.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.
- C. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
- F. Pipe-Label Colors:
 - 1. Background Color: Safety Red.
 - 2. Letter Color: White.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Pipe Markers.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
- B. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: aluminum, 0.032 inch or anodized aluminum, 0.032 inch thick, with predrilled holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain beaded chain or S-hook.
 - 3. Valve-Tag Color: Safety Red.
 - 4. Letter Color: White.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Carlton Industries, LP.
 - 4. Champion America.
 - 5. Craftmark Pipe Markers.
 - 6. emedco.
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Seton Identification Products.
- B. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit a view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:
 - 1. Valve-Tag Size and Shape:
 - a. Fire-Suppression Standpipe: 1-1/2 inches round.
 - b. Wet-Pipe Sprinkler System: 1-1/2 inches round.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 210553

SECTION 211119 - FIRE-DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Yard-type fire-department connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 YARD-TYPE FIRE-DEPARTMENT CONNECTION

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:
 - 1. Elkhart Brass Mfg. Company, Inc.
 - 2. Fire-End & Croker Corporation.
 - 3. Fire Protection Products, Inc.
 - 4. GMR International Equipment Corporation.
 - 5. Guardian Fire Equipment, Inc.
 - 6. Potter Roemer.
 - 7. Wilson & Cousins Inc.
- B. Standard: UL 405.
- C. Type: Exposed, freestanding.
- D. Pressure Rating: 175 psig minimum.
- E. Body Material: Corrosion-resistant metal.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Round, brass, floor type.
- I. Outlet: Bottom, with pipe threads.
- J. Number of Inlets: Four.
- K. Sleeve: Brass.
- L. Sleeve Height: As required
- M. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE."
- N. Finish, Including Sleeve: Polished chrome plated.
- O. Outlet Size: NPS 6.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.
- B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install yard-type fire-department connections in concrete slab support. Comply with requirements for concrete in Section 033000 "Cast-in-Place Concrete."
- B. Install **two** protective pipe bollards on sides of each fire-department connection. Comply with requirements for bollards in Section 055000 "Metal Fabrications."
- C. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 211119

SECTION 211200 - FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection specialty valves.
3. Hose connections.
4. Alarm devices.
5. Pressure gages.

- B. Related Requirements:

1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
2. Section 211313 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.

- C. Materials and installation shall fully comply with standards and requirements of factory mutual.

1.3 DEFINITIONS

- A. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig maximum.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For fire-suppression standpipes.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

- C. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include;

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.

- D. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and professional engineer.
- B. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- C. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

- A. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.

2.2 PERFORMANCE REQUIREMENTS

- A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.
- B. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Available fire-hydrant flow test: Perform fire hydrant flow test within ninety (90) days of delegation design submittal.
- C. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
 - 1. Minimum residual pressure at each hose-connection outlet is as follows:
 - a. NPS 2-1/2 Hose Connections: 100 psig.
- D. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials and for joining methods for specific services, service locations, and pipe sizes.

2.4 BLACK STEEL PIPE AND ASSOCIATED FITTINGS

- A. Schedule 40: ASTM A 53/A 53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.
- B. Schedule 40: ASTM A 135/A 135M, Grade A; with factory- or field-formed ends to accommodate joining method.
- C. Schedule 40: ASTM A 795/A 795M, Type E, Grade A; with factory- or field-formed ends to accommodate joining method.
- D. Schedule 10: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10.
- E. Uncoated, Steel Couplings: ASTM A 865/A 865M, threaded.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- F. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- G. Malleable- or Ductile-Iron Unions: UL 860.
- H. Cast-Iron Flanges: ASME B16.1, Class 125.
- I. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
- J. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
- K. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Corcoran Piping System Co.
 - c. National Fittings, Inc.
 - d. Shurjoint Piping Products.
 - e. Smith-Cooper International.
 - f. Tyco Fire & Building Products LP.
 - g. Victaulic Company.
 - 2. Pressure Rating: 175 psig minimum.
 - 3. Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.5 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
 - 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.6 SPECIALTY VALVES

- A. General Requirements:
 - 1. Standard: UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
 - 2. Pressure Rating: Standard-Pressure Piping Specialty Valves: 175 psig minimum.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

2.7 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Fire Protection Products, Inc.
 - c. Fire-End & Croker Corporation.
 - d. Kennedy Valve Company; a division of McWane, Inc.
 - e. Kidde Fire Fighting; A UTC Business Unit.
 - f. Mueller Co.
 - g. NIBCO INC.
 - h. Potter Roemer LLC.
 - i. Tyco Fire & Building Products LP.
 - j. Viking Corporation.
 - k. Wilson & Cousins Inc.
2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle.
9. Finish: Polished chrome-plated.

2.8 PRESSURE GAGES

- ### A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AMETEK, Inc.
 2. Ashcroft Inc.
 3. Brecco Corporation.
 4. WIKA Instrument Corporation.
- ### B. Standard: UL 393.
- ### C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- ### D. Pressure Gage Range Zero to 300 psig.

- E. Water System Piping Gage: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.

3.2 EXAMINATION

- A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.
- B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general a location and arrangement of piping and does not reflect a design intent or exact routing. The contractor is fully responsible for the delegated design submittal.
 - 1. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.
- C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
- D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install drain valves on standpipes. Extend drain piping to outside of building.
- F. Install alarm devices in piping systems.
- G. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

- H. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- I. Fill wet-type standpipe system piping with water.
- J. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- K. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

- J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

3.6 HOSE-CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes.
- B. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

3.7 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Start and run air compressors.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.

8. Verify that equipment hose threads are same as local fire-department equipment.
- C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.10 PIPING SCHEDULE

- A. Standard-pressure, wet-type fire-suppression standpipe piping, shall be one of the following:
 1. Schedule 40 black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 2. Schedule 40 black-steel pipe with cut-or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 3. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

END OF SECTION 211200

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SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Pipes, fittings, and specialties.
 - 2. Specialty valves.
 - 3. Sprinklers.
 - 4. Alarm devices.
 - 5. Pressure gages.

- B. Related Requirements:

- 1. Section 211119 "Fire Department Connections" for yard-type fire department connections.
 - 2. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

- C. Materials and installation shall fully comply with standards and requirements of factory mutual.

- D. Delegated design shall adhere to the requirements and standards of FM Global for the occupancy and application.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For wet-pipe sprinkler systems.

- 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include; drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.
- D. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer and professional engineer.
- B. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations.
- C. Fire-hydrant flow test report.
- D. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13.
 - 2. FM Global
 - 3. Authority Having Jurisdiction (AHJ).
- B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
 - 1. Fire-hydrant flow test:
 - a. Perform fire hydrant flow test within ninety (90) days of delegated design submittal.
 - 2. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: 20 percent, including losses through water-service piping, valves, and backflow preventers.
 - b. Sprinkler Occupancy Hazard Classifications:
 - 1) Building Service Areas: Ordinary Hazard, Group 1
 - 2) Electrical Equipment Rooms: Ordinary Hazard, Group 1
 - 3) General Storage Areas: Ordinary Hazard, Group 1
 - 4) Mechanical Equipment Rooms: Ordinary Hazard, Group 1
 - 5) Office and Public Areas: Light Hazard.
 - 3. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
 - c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
 - d. Special Occupancy Hazard: As determined by authorities having jurisdiction.
 - 4. Maximum Protection Area per Sprinkler: According to UL listing and FM Global guidelines.
 - 5. Maximum Protection Area per Sprinkler:
 - a. Office Spaces: 120 sq. ft.
 - b. Storage Areas: 130 sq. ft.
 - c. Mechanical Equipment Rooms: 130 sq. ft.
 - d. Electrical Equipment Rooms: 130 sq. ft.
 - e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
- D. Occupancy hazard classifications and minimum densities listed are the minimum acceptable design criteria. Where FM Global guidelines require or specify a higher occupancy classification or an increase in water flow densities/coverage, that criteria shall be used in lieu of these listings.

- E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Black Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Grooved in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to 8 NPS.
- C. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Uncoated Steel Couplings: ASTM A 865/A 865M, threaded.
- E. Uncoated Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- F. Malleable- or Ductile-Iron Unions: UL 860.
- G. Cast-Iron Flanges: ASME 16.1, Class 125.
- H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 - 1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch, nonmetallic and asbestos free or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
 - b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
 - 2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
- I. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements
 - a. Anvil International.
 - b. Corcoran Piping System Co.
 - c. National Fittings, Inc.
 - d. Shurjoint Piping Products.
 - e. Smith-Cooper International.
 - f. Tyco Fire & Building Products LP.
 - g. Victaulic Company.
 - 2. Pressure Rating: 175 minimum.
 - 3. casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
- J. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

2.3 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" and FM Global's "Approval Guide."
- B. Pressure Rating:
 - 1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Automatic (Ball Drip) Drain Valves:
 - 1. Manufacturers: Subject to compliance with requirements:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - 2. Standard: UL 1726.
 - 3. Pressure Rating: 175-psig minimum.
 - 4. Type: Automatic draining, ball check.
 - 5. Size: NPS 3/4
 - 6. End Connections: Threaded.

2.4 SPRINKLER PIPING SPECIALTIES

- A. Flow Detection and Test Assemblies:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - 2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 - 3. Pressure Rating: 175-psig minimum.
 - 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 - 5. Size: Same as connected piping.
 - 6. Inlet and Outlet: Threaded or grooved.
- B. Sprinkler Inspector's Test Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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Webster University
Cannon Design Project No. 004561.01

- a. AGF Manufacturing Inc.
 - b. Triple R Specialty.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 3. Pressure Rating: 175-psig.
 4. Body Material: Cast- or ductile-iron housing with sight glass.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.

2.5 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Globe Fire Sprinkler Corporation.
 2. Reliable Automatic Sprinkler Co., Inc. (The).
 3. Tyco Fire & Building Products LP.
 4. Viking Corporation.
- B. Listed in UL's "Fire Protection Equipment Directory" and FM Global's "Approval Guide."
- C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- D. Automatic Sprinklers with Heat-Responsive Element:
 1. Nonresidential Applications: UL 199 .
 2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- E. Sprinkler Finishes: Chrome plated or bronze.
- F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment.
 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- G. Sprinkler Guards:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 2. Standard: UL 199.

3. Type: Wire cage with fastening device for attaching to sprinkler.

2.6 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.

- B. Electrically Operated Alarm Bell:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Notifier.
 - c. Potter Electric Signal Company, LLC.
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 10-inch diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Subject to the approval of the Authority Having Jurisdiction (AHJ), an electrically operated horn/strobe may be substituted for the alarm bell as described. The horn/strobe shall be listed for outdoor use.

- C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ADT Security Services, Inc.
 - b. McDonnell & Miller.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 - e. Viking Corporation.
 - f. Watts; a Watts Water Technologies company.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

- D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- a. Barksdale, Inc.
 - b. Detroit Switch, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 - e. Tyco Fire & Building Products LP.
 - f. United Electric Controls Co.
 - g. Viking Corporation.
 2. Standard: UL 346.
 3. Type: Electrically supervised water-flow switch with retard feature.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design Operation: Rising pressure signals water flow.
- E. Valve Supervisory Switches:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Kennedy Valve Company; a division of McWane, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 2. Standard: UL 346.
 3. Type: Electrically supervised.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design: Signals that controlled valve is in other than fully open position.
 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AGF Manufacturing Inc.
 2. AMETEK, Inc.
 3. Ashcroft Inc.
 4. Brecco Corporation.
 5. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 300 psig .
- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.[Comply with requirements for backflow preventers in Section 211100 "Facility Fire-Suppression Water-Service Piping."]
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general a location and arrangement of piping and does not reflect a design intent or exact routing. The contractor is fully responsible for the delegated design submittal.
 - 1. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 and FM Global requirements for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with NFPA 13 and FM Global requirements for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- N. Pressurize and check pre-action sprinkler system piping, air-pressure maintenance devices and air compressors.
- O. Fill sprinkler system piping with water.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

- H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- J. to manufacturer's "Installation Manual" and NFPA 13 or NFPA 13R for supports.

3.5 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Specialty Valves:
 - 1. Install valves in vertical position for proper direction of flow, in main supply to system.
 - 2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.

3.6 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

3.7 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 CLEANING

- A. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.10 DEMONSTRATION

- A. Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.11 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:
1. Standard-weight black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 2. Standard-weight black-steel pipe with cut-or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 3. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 8, shall be one of the following:
1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 2. Standard-weight black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 3. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.12 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers, with wire cage guards.
 - 2. Rooms with Suspended Ceilings: Pendent, recessed, flush, and concealed sprinklers as indicated.
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Pendent, dry sprinklers.
 - 5. Special Applications: Extended-coverage, and quick-response sprinklers where indicated
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - 2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
 - 3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
 - 4. Upright, Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

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SECTION 211316 - DRY-PIPE PRE-ACTION SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, fittings, and specialties.
 - 2. Pre-Action Assembly.
 - 3. Sprinklers.
- B. Related Sections:
 - 1. Section 211313 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.

1.3 REFERENCES

- A. Underwriters Laboratories (UL):
 - 1. UL 260 – Dry Pipe and Deluge Valves for Fire Protection Service.
 - 2. UL 268 – Smoke Detectors for Fire Alarm Systems.
 - 3. UL 864, 9th Edition – Control Units and Accessories for Fire Alarm Systems.
 - 4. UL 2125 – Motor-Operated Air Compressors for Use in Sprinkler Systems (also see UL 1450).
- B. Factory Mutual (FM):
 - 1. Class Numbers 1011 / 1012 / 1013 – Deluge and Preaction Systems.
 - 2. Class Number 1020 – Automatic Water Control Valves.
 - 3. Class Number 3010 – Fire Alarm Signaling Systems.
 - 4. Class Number 3230 – Smoke Actuated Detectors for Automatic Fire Alarm Signaling.
 - 5. Property Loss Prevention Data Sheet 2-0 – Automatic Sprinkler Systems.
 - 6. Property Loss Prevention Data Sheet 5-40 – Fire Alarm Systems.
- C. National Fire Protection Association (NFPA):
 - 1. NFPA 13 – Installation of Sprinkler Systems.
 - 2. NFPA 70 – National Electrical Code.
 - 3. NFPA 72 – National Fire Alarm and Signaling Code.

1.4 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Dry-pipe pre-action sprinkler system piping designed to operate at working pressure 175 psig maximum.

1.5 SYSTEM DESCRIPTIONS

- A. Furnish and install water-based pre-action fire suppression system using self-contained double interlock pre-action assembly that contains all mechanical and electrical components required.
- B. Single steel enclosures factory assembled.
- C. Preaction valve factory-assembled to inlet tee.
- D. Air maintenance device factory-assembled in enclosure.
- E. Compressor to provide supervisory air pressure, factory assembled to rubber mounts, pre-wired to shut-off switch in upper enclosure, and factory connected to pre-action valve.
- F. Three pressure gages factory assembled and visible through cutouts in lower enclosure without opening lower enclosure door.
 - 1. System Air Pressure.
 - 2. Water Supply Pressure.
 - 3. Valve Line Pressure.
- G. Manual release handle behind separate non-lockable access.
- H. Integral addressable control panel factory-assembled and wired
- I. The assembly shall be pre-assembled, pre-wired, and fully factory tested as a system by the manufacturer. Assemblies using non-addressable control panels shall not be accepted.
- J. Furnish and install intelligent, spot smoke detectors. The detectors shall be photoelectric
- K. Double-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air. Actuation of a fire-detection system in the same area as sprinklers opens the deluge valve permitting water to flow into the sprinkler piping; a closed solenoid valve in the sprinkler piping is opened by another fire-detection device; then water will discharge from sprinklers that have opened.

1.6 PERFORMANCE REQUIREMENTS

- A. Design and performance of systems, components, and methods specified herein shall comply with all applicable referenced codes and standards.
- B. Contract drawings indicate the general arrangement of the system and are a guide for intent only. Contractor is responsible for providing and installing all equipment necessary to complete the installation in compliance with all applicable requirements.
- C. Contractor shall design, furnish, and install the dry-pipe pre-action sprinkler system(s) per this specification, and shall provide Professional Engineering services needed to assume Engineering responsibility.
- D. Contractor is responsible for system layout in the fire zones indicated as "Pre-Action" on the contract drawings, including spacing and location of sprinkler heads, pipe size and pipe routing,

location and number of pre-action enclosures, and all other details required by applicable standards.

E. All equipment and materials shall be new and unused.

F. Fire Detection Design.

1. Standards.

1. FM Property Loss Prevention Sheet 5-40 – Fire Alarm Systems.
2. FM Number 3010 – Fire Alarm Signaling Systems.
3. NFPA 70 – National Electrical Code.
4. NFPA 72 – National Fire Alarm Code.

G. Requirements.

1. Power.

1. Primary. Primary power shall be from a 110VAC dedicated branch circuit. A primary power calculation that details the power requirements for the Control Unit and all field devices such as smoke detectors, notification appliances and releasing solenoids shall be performed.
2. Standby. Standby power shall be provided by rechargeable gel-cell batteries installed in the enclosure. A secondary power calculation that shows the quiescent and alarm power requirements for the Control Unit and all field devices shall be performed.
3. Quiescent power requirement = 24 hours.
4. Alarm power requirement = 5 minutes.
5. Wire Sizes. Voltage drop calculations shall be performed justifying the wire sizes of all 24 VDC circuits.

2. System Operation - Double Interlock

1. The activation of both a single electric fire detector AND the activation by heat of an automatic sprinkler head are necessary to cause water to discharge.
2. The activation of an electric fire detector BEFORE activation by heat of an automatic sprinkler head shall:
 - a. Put integral control panel into alarm condition.
 - b. Activate solenoid on trim of pre-action valve in Preaction-Pac lower enclosure.
 - c. NOT allow water to enter the sprinkler piping.
3. The activation by heat of an automatic sprinkler head AFTER activation of an electric fire detector shall:
 - a. Allow water to enter the sprinkler piping.
 - b. Discharge water from activated sprinkler heads.
4. The activation by heat of an automatic sprinkler head OR a break or air leak in the sprinkler piping BEFORE activation of an electric fire detector shall:
 - a. Put integral control panel into SUPERVISORY condition.
 - b. NOT permit water to enter the sprinkler piping.
5. Operation of the emergency manual release valve integral with the PREACTION-PAC™ shall open the pre-action valve and allow water to enter the sprinkler piping.

- H. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- I. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- J. Sprinkler system design shall be approved by authorities having jurisdiction.
- K. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.7 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For dry-pipe pre-action sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include; drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.
- D. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

1.8 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer and professional engineer.
- B. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- C. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- D. Field quality-control reports.

1.9 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.10 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.
 - 2. Locate cabinet in the same room as the cabinet.

1.11 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. .
 - 1. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."

1.12 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, building structure and partition assemblies.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

- A. Standard Weight, Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

- B. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- C. Galvanized, Steel Couplings: ASTM A 865, threaded.
- D. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- E. Malleable- or Ductile-Iron Unions: UL 860.

2.3 LISTED FIRE-PROTECTION VALVES

- A. Valves shall be UL listed or FM approved.

2.4 PRE-ACTION SYSTEM

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. FireFlex Systems Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. United Fire Systems

2.1 PREACTION SYSTEM ASSEMBLY. Furnish and install factory-wired and factory-tested self-contained double interlock pre-action assembly containing all mechanical and electrical components required. The assembly shall contain all components factory-assembled and tested to make up a complete, ready-to-install device. The assembly shall consist of:

- A. Standard: FM Class Numbers 1011 / 1012 / 1013 – Deluge and Preaction Systems.
- B. Enclosure.
 - 1. Steel enclosures factory assembled.
 - 2. Minimum 14 gage steel with continuous welded seams.
 - 3. Enclosure finished in powder-coat red paint.
 - 4. Equipped with lockable access doors.
 - 5. Access door for manual release handle separate from enclosure doors. No key lock shall be installed on manual release handle door.
 - 6. All doors equipped with full piano hinge and oil-resistant gaskets.
- C. Fire Protection Valve.
 - 1. General Requirements.
 - a. The valve shall be a low-differential, latched clapper valve that uses the supply water pressure from upstream of the main control valve to hold the clapper shut. When the water pressure in the diaphragm chamber is released, the latch is retracted and the valve actuates.
 - b. Valve shall be self-resetting and no disassembly or cover removal shall be required for reset.

- c. Valve shall be rated for no less than 300 PSIG water working pressure, and factory hydrostatically tested to a minimum of 600 PSIG.
 - d. Minimum required supervisory gas pressure shall be 13 PSIG.
 - e. No separate check valve shall be required.
 - f. Valve shall be factory-assembled to an inlet tee secured to the bottom of the lower enclosure.
 - g. The full trim for the preaction valve shall be factory-assembled. No field modifications of the valve trim shall be permitted.
- 2. Standards.
 - 1. UL 260 – Dry Pipe and Deluge Valves for Fire Protection Service.
 - 2. Factory Mutual (FM) Class Number 1020 – Automatic Water Control Valves.
- 3. Operation.
 - a. Operation. The valve shall operate as a double-interlock pre-action valve with electric release. When the electric solenoid is operated by the control panel AND the supervisory gas is exhausted by the operation of an automatic sprinkler head, the water in the diaphragm chamber shall be released and the valve shall open.
- D. Compressor.
 - 1. General Requirements.
 - a. Factory assembled into lower enclosure, wired and attached to preaction valve.
 - b. Compressor shall be sized to restore normal air pressure in the pre-action system piping in 30 minutes or less.
 - c. Compressor shall be of the oil-less piston type, equipped with a pressure switch and a bubble-tight check valve.
 - d. Power: 110 VAC 60 Hz, 1 phase.
 - e. Standard: UL 2125 – Motor-Operated Air Compressors for Use in Sprinkler Systems (also see UL 1450).
- E. Control Panel, integrated, and factory wired, and integral with pre-action sprinkler cabinet,
 - 1. General Requirements.
 - a. Factory-assembled into enclosure.
 - b. Factory-wired to release solenoid in lower enclosure.
 - c. Visible through polycarbonate window in upper enclosure door.
 - d. Listed and approved for pre-action release service.
 - 2. Standards.
 - a. UL 864, 9th Edition – Control Units and Accessories for Fire Alarm Systems.
 - b. Factory Mutual (FM) Class Number 3010 – Fire Alarm Signaling Systems.
 - 3. Specific Product Requirements.
 - a. Control panel shall be a addressable control panel, and shall consist of:
 - b. A printed circuit board (PCB), with:
 - 1. Main system microprocessor.
 - 2. Real-time clock.
 - 3. History buffer.
 - 4. An integral display / control assembly.
 - 5. Watchdog timer.
 - 6. One (1) USB device port.
 - 7. Two (2) RS-232 serial ports.
 - 8. Terminations for field circuits.

- c. Field circuits shall include:
 - 1. One (1) signaling line circuit (SLC). The SLC shall serve as the hardware and software interface between the intelligent initiating and control devices and the control panel. The SLC shall be capable of communicating with up to 255 fire detectors, monitor modules, and control devices, in any combination, without restrictions on the number of each type of device.
 - 2. Two (2) notification appliance circuits (NACs), independently programmable and configurable for either Class A or B operation. It shall not be necessary to use external synchronization modules to synchronize the audible and visual notification signals created by any NAC.
 - 3. Two (2) releasing circuits.
 - 4. Two (2) combination NAC / releasing circuits (Combos).
 - 5. Three (3) programmable volt-free relay contacts.
 - 6. One (1) volt-free trouble relay contact.
 - 7. One (1) RS-485 communications circuit.
 - 8. One (1) circuit for connection of secondary battery, providing for changeover to secondary power upon loss of primary power, and charging of battery when primary power is present.
- d. . A primary power supply / charger assembly, consisting of an AC to DC switching power unit. The power-supply / charger assembly shall be factory configured to accept 120 VAC input voltage, and shall provide 5.4 A at 24 VDC of filtered and regulated power to operate the system and charge the system's standby batteries. Two user-configurable auxiliary-power circuits shall be provided on the PCB to power peripheral devices. The auxiliary-power circuits shall be software programmable for either continuous or interruptible power output, and shall be rated for 1.0 A at 24 VDC. It shall not be necessary to set jumpers or dip switches on the PCB to make these outputs continuous or interruptible.
- e. Operator Switches and Interface.
 - 1. Switch - Event Acknowledgment.
 - 2. Switch - Alarm Silence.
 - 3. Switch - Scroll.
 - 4. Switch - System Reset.
 - 5. Status LEDs – Power On, Alarm, Pre-Alarm, Trouble, Supervisory, Silence.
 - 6. 12-key numeric keypad with BACKSPACE and ENTER keys.
 - 7. 80-character backlit liquid crystal display (LCD).
- f. Programming.
 - 1. Control panel shall be programmable and configurable in the field without programming of PROM chips or replacement of memory chips.
 - 2. Programming shall allow any input to activate any output or group of outputs. Systems with limited programming capability or complex hardware programming (such as a diode matrix) are not considered suitable.
- g. Communication.
 - 1. The control panel shall communicate with all initiating devices via a digital data protocol, transmitted over a two-wire signaling line circuit (SLC).
 - 2. Each point on the SLC shall have a unique address, permitting point identification of fire location and detector faults.
 - 3. The communication protocol used by the control panel over the SLC shall provide complete supervision of wiring and detector status.

- h. Contacts. Dry contacts shall be provided for signaling the building fire alarm system.
1. Alarm. Contact operates on any fire alarm signal processed by the control panel.
 2. Trouble. Contact operates on any fault reported by the control panel.
 3. Supervisory. Contact operates on any supervisory signal processed by the control panel.

G. Addressable Monitor Modules.

1. Low air sensor switch.
2. Tamper switch.
3. Waterflow sensor switch.
4. Addressable Output Module
5. General Requirements
6. Factory-wired to valve releasing solenoid.

H. Other

1. (3) pressure gages factory assembled and visible through cutouts in lower enclosure without opening lower enclosure door.
2. System Air Pressure
3. Water Supply Pressure
4. Valve Line Pressure
5. Manual release handle behind separate non-lockable door in lower enclosure.
6. Printed instructions visible with door closed through polycarbonate window in enclosure door.
7. Knockouts provided in upper enclosure for attachment of external electrical conduits.
8. Space for required spare sprinkler heads and sprinkler wrench in upper enclosure. No separate spare sprinkler head enclosure shall be permitted.
9. All wiring for complete system installed at factory.
10. Inlet for water supply in lower portion of enclosure.
11. Outlet for water to sprinklers on top portion of enclosure.
12. 120VAC, 60 Hz, single phase connection point in upper enclosure to serve both control panel and compressor. If necessary, jumpers may be removed to permit separate 120VAC connections for control panel and compressor.
13. Assembly to be FM Approved and marked with FM Approval mark on inside of enclosure.

2.1 FIRE DETECTORS - SPOT SMOKE DETECTION

- A. General Requirements. The control panel's distributed intelligence shall extend to the SmartOne automatic initiating devices on the signaling line circuit. Each automatic initiating device shall have a microprocessor capable of independently determining whether or not a fire signature at its monitored location is of sufficient magnitude to warrant the issuance of an alarm signal to the control unit.
- B. Standards.
1. UL 268 – *Smoke Detectors for Fire Alarm Systems*.
 2. FM Class Number 3230 – *Smoke Actuated Detectors for Automatic Fire Alarm Signaling*.
- C. Photoelectric Smoke Detector.

1. The Photoelectric Smoke Detector, shall be a microprocessor-based smoke detector. The detector shall be a light scattering type, low profile, intelligent detector that senses a broad range of smoldering and flaming-type fires. The sensing chamber shall permit a full 360° smoke entry.

2. Each photoelectric smoke detector shall be electronically addressable and fully field-programmable. It shall be possible to set an alert threshold anywhere from 0.2 to 3.4% per foot obscuration in 0.1%-per-foot increments, and to set an alarm threshold anywhere from 0.5 to 3.5% per foot obscuration in 0.1%-per-foot increments. Alarm thresholds shall be dynamically adjustable as a result of another alarm event anywhere in the system. Where permitted, each detector shall be programmable for alarm verification in periods of up to 180 seconds in 1-second increments. Each detector shall provide a real-time value of current, local obscuration level in percent-per-foot readout when requested by an operator at the control unit.
3. It shall be possible to configure each photoelectric detector for non-latching operation to prevent inadvertent or spurious fire signatures from accidentally discharging a waterless extinguishing system. The control unit shall latch the alarm report, but the discharge sequence shall be interrupted if the fire signature at the detector drops below the detector's programmable alarm threshold.
4. Detector calibration, address, alert and alarm thresholds, and drift-compensation algorithm shall be stored in each detector's non-volatile memory. Systems that store all detector parameters in the control unit (i.e., non-distributed-intelligence-to-the-device-level architecture) shall not be considered as equivalent.

2.2 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following as listed in Section 211312 Wet Pipe Sprinkler system.
- B. General Requirements:
 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
- C. Automatic Sprinklers with Heat-Responsive Element:
 1. Characteristics: Nominal 1/2-inch orifice with discharge coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- D. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, are specified with sprinklers.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

- B. Piping Standard: Comply with requirements in NFPA 13 for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes 2 NPS and smaller.
- F. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.
- G. Drain dry-pipe sprinkler piping.
- H. Pressurize and check dry-pipe sprinkler system piping and air compressor.
- I. Install sleeves for piping penetrations of walls and ceilings,. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- J. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.2 JOINT CONSTRUCTION

- A. Install couplings, fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes 2 NPS and smaller.
- C. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- D. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- F. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.3 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Start and run air compressors.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.
- C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.
- B. Provide all printed materials in the OEM and on CD/DVD.
- C. Provide video recording of session.

3.8 PIPING SCHEDULE

- A. Standard-pressure, dry-pipe pre-action sprinkler system, NPS 2 and smaller, shall be the following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

END OF SECTION 211316

SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Horizontally mounted, multistage, split-case fire pumps..
 - 2. Fire-pump accessories and specialties.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include; drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.
- D. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of fire pump, from manufacturer.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Comply with NFPA 20.
- B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event[.]".
 - 2. Component Importance Factor: 1.5.
- C. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

- A. Description: Factory-assembled and -tested fire-pump and driver unit.
- B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A-C Fire Pump; a Xylem brand.
 - 2. Pentair Pump Group.
- E. Pump:
 - 1. Standard: UL 448, for split-case pumps for fire service.
 - 2. Casing: Axially split case, cast iron, with ASME B16.1 pipe-flange connections.
 - 3. Impeller: Double suction, cast bronze, statically and dynamically balanced, and keyed to shaft.
 - 4. Wear Rings: Replaceable bronze.
 - 5. Shaft and Sleeve: Alloy steel shaft with bronze sleeve.
 - a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 - 6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
- F. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
- G. Driver:
 - 1. Standard: UL 1004].
 - 2. Type: Electric motor; NEMA MG 1, polyphase Design B.
- A. Capacities and Characteristics: This equipment shall be sized and selected in conjunction with the delegated design submittal. Unit selected shall be fully coordinated and purchased with the controller for a complete operating system.
 - 1. Rated Capacity: 1000 gpm
 - 2. Inlet Flange: Class 250.
 - 3. Outlet Flange: Class 250.
 - 4. Suction Head Available at Pump: Contractor to preform fire hydrant flow test to establish design criteria for the delegated design submittal.
 - 5. Motor Horsepower: 40 hp maximum. The electrical design for the building has accounted for a 40 HP electrical motor. The design building contractor may not select a pump which exceeds 40 hp demand without prior written approval by the electrical engineer.

2.3 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
- B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
- C. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

- D. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
- E. Discharge Cone: Closed or open type, as required by the application.
- F. Hose Valve Manifold Assembly:
 - 1. Standard: Comply with requirements in NFPA 20.
 - 2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with grooved ends.
 - 3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - 4. Automatic Drain Valve: UL 1726.
 - 5. Manifold:
 - a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
 - b. Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
 - c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
 - d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - e. Escutcheon Plate: Brass or bronze; rectangular.
 - f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - g. Exposed Parts Finish: chrome plated.
 - h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.4 GROUT

- A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink and recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - 1. Verification of Performance: Rate fire pumps according to UL 448.
- B. Fire pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.
- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
- D. Support piping and pumps separately, so weight of piping does not rest on pumps.
- E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes" and Section 211313, "Wet-Pipe Sprinkler Systems."
- F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes" and Section 211313, "Wet-Pipe Sprinkler Systems."
- G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
- H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
- I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 ALIGNMENT

- A. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connections.
- D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.4 CONNECTIONS

- A. Comply with requirements for piping and valves specified in [Section 211200 "Fire-Suppression Standpipes." and Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps and equipment to allow service and maintenance.
- C. Connect relief-valve discharge to drainage piping or point of discharge.
- D. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

- A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Witnesses: Provide notification to engage the services of; the owners representative, FM Global and the Authority Having jurisdiction (AHJ) to be present and witness the testing of this equipment.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
 - 2. Test according to NFPA 20 for acceptance and performance testing.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Provide all printed materials with OEM and on CD/DVD.
 3. Provide video recording of the session.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.
- B. Provide all printed materials in OEM and on CD/DVD.
- C. Provide a video recording of session.

END OF SECTION 213113

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SECTION 213400 - PRESSURE-MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Vertical, multistage, pressure-maintenance pumps.
- B. Related Requirements:
 - 1. Section 213900 "Controllers for Fire-Pump Drivers" for pressure-maintenance-pump controllers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For pumps, accessories, and specialties.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include; drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.
- D. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 VERTICAL, MULTISTAGE, PRESSURE-MAINTENANCE PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A-C Fire Pump; a Xylem brand.
 - 2. Aquarius Fluid Products, Inc.
 - 3. Grundfos Management A/S.
 - 4. PACO Pumps; Grundfos Pumps Corporation, USA.
 - 5. TACO Incorporated.
- B. Description: Factory-assembled and -tested, multistage, barrel-type vertical pump as defined in HI 2.1-2.2 and HI 2.3; designed for surface installation with pump and motor direct coupled and mounted vertically.
- C. Pump Construction:
 - 1. Barrel: Stainless steel.
 - 2. Suction and Discharge Chamber: Cast iron with flanged inlet and outlet.
 - 3. Pump Head/Motor Mount: Cast iron.
 - 4. Impellers: Stainless steel, balanced, and keyed to shaft.
 - 5. Pump Shaft: Stainless steel.
 - 6. Seal: Mechanical type with carbon rotating face and silicon-carbide stationary seat.
 - 7. Wear Rings: Teflon.
 - 8. Intermediate Chamber Bearings: Aluminum-oxide ceramic or bronze.
 - 9. Chamber-Base Bearing: Tungsten carbide.
 - 10. O-Rings: Viton.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
- F. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet long.
- G. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

- H. Capacities and Characteristics: This equipment shall be sized and selected in conjunction with the delegated design submittal. Unit selected shall be fully coordinated and purchased with the controller for a complete operating system.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
 - 1. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.
- B. Equipment Mounting:
 - 1. Install multistage, pressure-maintenance pumps according to HI 1.4.
 - 2. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in [Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - a. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
 - b. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Attach pumps to equipment base using anchor bolts.
 - g. Shim pumps as needed to make them level.
 - 3. Install isolation valves in both inlet and outlet pipes near the pump. Comply with requirements for valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Witnesses: Provide notification to engage the services of; the owners representative, FM Global and the Authority Having jurisdiction (AHJ) to be present and witness the testing of this equipment.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.3 ADJUSTING

- A. Lubricate pumps as recommended by manufacturer.
- B. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 213400

SECTION 213900 - CONTROLLERS FOR FIRE-PUMP DRIVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Full-service, full voltage controllers rated 600 V and less.
 - 2. Controllers for pressure-maintenance pumps.
 - 3. Low-suction-shutdown panels.

1.3 DEFINITIONS

- A. ATS: Automatic transfer switch(es).
- B. ECM: Electronic control module.
- C. MCCB: Molded-case circuit breaker.
- D. N.O.: Normally open.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-pump controllers and alarm panels shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each type of product indicated. Include dimensioned plans, elevations, sections, details, and attachments to other work, including required clearances and service spaces around controller enclosures.
 - 1. Show tabulations of the following:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Each installed unit's type and details.
 - b. Enclosure types and details for types other than NEMA 250, Type 2.
 - c. Factory-installed devices.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of integrated unit.
 - f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - g. Specified modifications.
 2. Detail equipment assemblies and indicate dimensions, weights, loads, method of field assembly, components, and location and size of each field connection.
 3. Schematic and Connection Diagrams: For power, signal, alarm, and control wiring and for pressure-sensing tubing.
- C. Controllers must be designed and purchased with the fire pump and pressure maintenance pump. All equipment shall be fully compatible and operational.
- D. Delegated Design: The fire suppression contractor has full responsibility to prepare and submit a completed engineered fire suppression system design, including but not limited to; fire hydrant flow test, fire pumps, pressure maintenance pump, controllers, standpipe system, pre-action double interlock system, backflow device, piping, fittings, valves, sprinkler heads, etc. Delegated design shall be submitted for review in the shop drawing process and to include; drawings, details, components and equipment cut sheets, calculations, flow test report and results. Submittal shall be sealed and signed by a registered professional engineer.
- E. The contractor is responsible to adhere to the requirements of NFPA, FM Global and the authority having jurisdiction (AHJ), whether specifically addressed in these construction documents or not.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Certificates: For each type of product indicated, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Product Certificates: For each type of product indicated, from manufacturer.
- D. Manufacturer's factory test reports of fully assembled and tested equipment.
- E. Source quality-control reports.
- F. Field quality-control reports.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - 2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor-based logic controls.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of an NRTL.
- B. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with standards of authorities having jurisdiction pertaining to materials and installation.
- E. Comply with NFPA 20 and NFPA 70.
- F. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, protect controllers from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

1.10 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Ambient Temperature Rating: Not less than 40 deg F and not exceeding 122 deg unless otherwise indicated.
 - 2. Altitude Rating: Not exceeding 6600 feet unless otherwise indicated.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1.11 COORDINATION

- A. Coordinate layout and installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 FULL-SERVICE CONTROLLERS

- A. Controllers must be designed and purchased with the fire pump and pressure maintenance pump. All equipment shall be fully compatible and operational.
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Aquarius Fluid Products, Inc.
 - 2. ASCO Power Technologies, LP; Firetrol Products.
 - 3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 4. Hubbell Incorporated; Hubbell Industrial Controls.
 - 5. Joslyn Clark Corporation.
 - 6. Master Control Systems, Inc.
- C. General Requirements for Full-Service Controllers:
 - 1. Comply with NFPA 20 and UL 218.
 - 2. Listed by an NRTL for electric-motor driver for fire-pump service.
 - 3. Combined automatic and non-automatic operation.
 - 4. Factory assembled, wired, and tested; continuous-duty rated.
 - 5. Service Equipment Label: NRTL labeled for use as service equipment.
- D. Method of Starting:
 - 1. Pressure-switch actuated.
 - a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - b. System pressure recorder, electric ac driven, with spring backup.
 - c. Programmable minimum-run-time relay to prevent short cycling.
 - d. Programmable timer for weekly tests.
 - 2. Magnetic Controller: Wye-delta, open transition.
 - 3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.
- E. Method of Stopping: Automatic and non-automatic shutdown after automatic starting.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- F. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.
- G. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.
- H. Door-Mounted Operator Interface and Controls:
 - 1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 2. Method of Control and Indication:
 - a. Microprocessor-based logic controller, with multiline digital readout.
 - b. Membrane keypad.
 - c. LED alarm and status indicating lights.
 - 3. Local and Remote Alarm and Status Indications:
 - a. Controller power on.
 - b. Motor running condition.
 - c. Loss-of-line power.
 - d. Line-power phase reversal.
 - e. Line-power single-phase condition.
 - 4. Audible alarm, with silence push button.
 - 5. Non-automatic START and STOP push buttons or switches.
- I. Optional Features:
 - 1. Extra Output Contacts:
 - a. One N.O. contact for motor running condition.
 - b. One set of contacts for loss-of-line power.
 - c. One each, Form C contacts for high and low reservoir level.
 - 2. Local alarm bell.
 - 3. Door-mounted thermal or impact printer for alarm and status logs.
 - 4. Operator Interface Communications Ports: USB, Ethernet, and RS485.
- J. ATS:
 - 1. Complies with NFPA 20, UL 218 and UL 1008.
 - 2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 - 3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 - 4. Allows manual transfer from one source to the other.
 - 5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
 - 6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

with non-thermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.

7. Local and Remote Alarm and Status Indications:
 - a. Normal source available.
 - b. Alternate source available.
 - c. In normal position.
 - d. In alternate position.
 - e. Isolating means open.
8. Audible alarm, with silence push button.
9. Non-automatic (manual, nonelectric) means of transfer.
10. Engine test push button.
11. Start generator output contacts.
12. Timer for weekly generator tests.

2.2 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Aquarius Fluid Products, Inc.
 2. ASCO Power Technologies, LP; Firetrol Products.
 3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 4. Hubbell Incorporated; Hubbell Industrial Controls.
 5. Joslyn Clark Corporation.
 6. Master Control Systems, Inc.
- B. General Requirements for Pressure-Maintenance-Pump Controllers:
 1. Type: UL 508 factory assembled, -wired, and tested, across-the-line; for combined automatic and manual operation.
 2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
 3. Factory assembled, wired, and tested.
 4. Finish: Manufacturer's standard color paint.
- C. Rate controller for scheduled horsepower and include the following:
 1. Fusible disconnect switch.
 2. Pressure switch.
 3. Hand-off-auto selector switch.
 4. Pilot light.
 5. Running period timer.

2.3 LOW-SUCTION-SHUTDOWN PANELS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Aquarius Fluid Products, Inc.
 2. ASCO Power Technologies, LP; Firetrol Products.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3. Hubbell Incorporated; Hubbell Industrial Controls.
4. Joslyn Clark Corporation.
5. Master Control Systems, Inc.

B. General Requirements for Low-Suction-Shutdown Panels:

1. Listed by an NRTL for fire-pump service.
2. Factory assembled, wired, and tested.
3. Prevents automatic start of fire pump, and shuts down automatically started fire pump, on low-suction pressure.
4. Automatic Manual reset.

C. Operation: External contact input or Integral pressure switch.

D. Supervisory and Normal Control Voltage: 120-V ac; dual source.

E. Include audible and visual alarms and status indications, with silence push button, for the following conditions:

1. Control power available.
2. Low-suction pressure.
3. Normal-suction pressure.

2.4 ENCLOSURES

A. Fire-Pump Controllers, ATS, Remote Alarm Panels, and Low-Suction-Shutdown Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.

1. Indoor Locations Subject to Dripping Noncorrosive Liquids: Type 2 (IEC IP11) .

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

2.5 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.

1. Verification of Performance: Rate controllers according to operation of functions and features specified.

B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.
- B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROLLER INSTALLATION

- A. Install controllers within sight of their respective drivers.
- B. Connect controllers to their dedicated pressure-sensing lines.
- C. Floor-Mounting Controllers: Install controllers on 4-inch nominal-thickness concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches above finished floor. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- F. Comply with NEMA ICS 15.

3.3 LOW-SUCTION-SHUTDOWN PANEL INSTALLATION

- A. Install panels on walls with tops not higher than 72 inches above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3.4 POWER WIRING INSTALLATION

- A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 CONTROL AND ALARM WIRING INSTALLATION

- A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
- B. Install wiring between remote alarm and low-suction-shutdown panels and controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 283111 "Digital, Addressable Fire-Alarm System."
- D. Bundle, train, and support wiring in enclosures.
- E. Connect remote manual and automatic activation devices where applicable.

3.6 IDENTIFICATION

- A. Comply with requirements in NFPA 20 for marking fire-pump controllers.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
 - 1. Inspect and Test Each Component:
 - a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.

- b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - c. Test continuity of each circuit.
 - 2. Verify and Test Each Electric-Driver Controller:
 - a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Architect, Construction Manager and Owner before starting the motor(s).
 - b. Test each motor for proper phase rotation.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - E. Field Acceptance Tests:
 - 1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to [Architect, Construction Manager, Owner and authorities having jurisdiction.
 - 2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - 3. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - 4. Perform field acceptance tests as outlined in NFPA 20.
 - F. Controllers will be considered defective if they do not pass tests and inspections.
 - G. Prepare test and inspection reports.
- 3.8 STARTUP SERVICE
- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Provide all printed materials with OEM and on CD/DVD.
 - 3. Provide a video recording of the session.
- 3.9 ADJUSTING
- A. Adjust controllers and battery charger systems to function smoothly and as recommended by manufacturer.
 - B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
 - C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- D. Set field-adjustable pressure switches.

3.10 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controllers, remote alarm panels, low-suction-shutdown panels and to use and reprogram microprocessor-based controls within this equipment.
- B. Provide all printed materials in the OEM and on CD/DVD.
- C. Provide a video recording of the session.

END OF SECTION 213900

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SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

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SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.

2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel or Stainless steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. HOLDRITE.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls above Grade:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and larger; Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves.
- 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller than NPS 6; Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and larger; Cast-iron wall sleeves with sleeve-seal system or Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
- 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and larger; Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system or Galvanized-steel-pipe sleeve-seal system
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
- 4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger; Galvanized-steel-pipe sleeves.
- 5. Interior Partitions:
 - a. Piping Smaller Than NPS 6; Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger; Galvanized-steel-sheet sleeves.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fastener.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with rough-brass finish.
 - f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with rough-brass finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Liquid-in-glass thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.
 - 4. Gage attachments.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab inc.
 - b. Palmer Wahl Instrumentation Group.
 - c. Terice, H. O. Co.
 - d. Weiss Instruments, Inc.
 - e. Weksler Glass Thermometer Corp.
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum nominal size unless otherwise indicated.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass or plastic
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Ernst Flow Industries.
 - c. Marsh Bellofram.
 - d. Palmer Wahl Instrumentation Group.
 - e. Terice, H. O. Co.
 - f. Watts; a Watts Water Technologies company.
 - g. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Brass or Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston or porous-metal type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball or Brass or stainless-steel needle, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending one-third of pipe diameter to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- G. Install thermometers in the following locations:
 1. Inlet and outlet of each water heater.
- H. Install pressure gages in the following locations:
 1. Building water service entrance into building.
 2. Inlet and outlet of each pressure-reducing valve.
 3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

- A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each domestic water heater shall be the following:
 - 1. Industrial-style, liquid-in-glass type.
- B. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F and minus 20 to plus 50 deg.
- B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F and 0 to 150 deg C.

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages shall be the following:
 - 1. Liquid-filled-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range: 0 to 160 psi and 0 to 1100 kPa.

END OF SECTION 220519

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Bronze ball valves.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve.
 - 1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and soldered ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.18 for solder-joint connections.
 - 5. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
 - 2. Handlever: For quarter-turn valves smaller than NPS 3.
- H. Valves in Insulated Piping:
 - 1. Include 2-inch stem extensions.
 - 2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Bronze Ball Valves with Full Port and Stainless-Steel Trim:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jomar Valve.
 - b. KITZ Corporation.
 - c. Milwaukee Valve Company.
 - 2. Description:
 - a. Standard: MSS SP-110.

- b. CWP Rating: 600 psig.
- c. Body Design: Two piece.
- d. Body Material: Forged brass.
- e. Ends: Threaded and soldered.
- f. Seats: PTFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel, vented.
- i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Valves: May be provided with solder-joint ends instead of threaded ends.
2. Two-piece, bronze ball valves with full port and stainless-steel trim.

B. Pipe NPS 2-1/2 and Larger:

1. Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

END OF SECTION 220523.12

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Bronze lift check valves.
 - 2. Bronze swing check valves.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve.
 - 1. Certification that products comply with NSF 61 and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect valve ends.
 - 3. Set check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 3. ASME B16.18 for solder joint.
 - 4. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE LIFT CHECK VALVES

- A. Class 125, Lift Check Valves with Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Valves.
 - 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig .
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: Bronze.

2.3 BRONZE SWING CHECK VALVES

- A. Class 125, Bronze, Swing Check Valves with Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Valves.
 - d. Hammond Valve.
 - e. Kitz Corporation.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Red-White Valve Corporation.
 - 2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.

- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Lift Check Valves: With stem upright and plumb.
- F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. End Connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Threaded.
 - 3. For Grooved-End Copper Tubing and Steel Piping: Grooved.

3.5 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE 150 PSIG OR LESS

- A. Pipe NPS 2 and Smaller:
 - 1. Vertical, Upflow Applications Only: Bronze lift check valves, Class 125, bronze disc with soldered or threaded end connections.
 - 2. Horizontal and Vertical Applications: Bronze swing check valves, Class 125, bronze disc with soldered or threaded end connections.

3.6 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 4 and Smaller: Bronze swing check valves, Class 125, bronze, metallic disc with soldered, threaded or grooved end connections.

END OF SECTION 220523.14

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SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Pipe positioning systems.
 - 6. Equipment supports.
- B. Related Sections:
 - 1. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Pipe stands.
 - 4. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.7 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.
 - c. Flex-Strut Inc.
 - d. Thomas & Betts Corporation; A Member of the ABB Group.
 - e. Unistrut; Part of Atkore International.
 - f. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturred lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
7. Metallic Coating: Electroplated zinc or Mill galvanized Mechanically-deposited zinc.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carpenter & Paterson, Inc.
 2. Clement Support Services.
 3. ERICO International Corporation.

4. National Pipe Hanger Corporation.
 5. PHS Industries, Inc.
 6. Pipe Shields Inc.
 7. Piping Technology & Products, Inc.
 8. Rilco Manufacturing Co., Inc.
 9. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig] or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE POSITIONING SYSTEMS

- A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.7 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. C-Clamps (MSS Type 23): For structural shapes.
 6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

- Q. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Elastomeric isolation pads.
 - 2. Elastomeric isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Pipe-riser resilient supports.
 - 5. Resilient pipe guides.
 - 6. Elastomeric hangers.
 - 7. Restraint channel bracings.
 - 8. Restraint cables.
 - 9. Seismic-restraint accessories.
 - 10. Mechanical anchor bolts.
 - 11. Adhesive anchor bolts.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES, OSHPD an agency acceptable to authorities having jurisdiction.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- b. Annotate to indicate application of each product submitted and compliance with requirements.
 - 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
 - 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.
- C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 - 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
 - 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
 - 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control reports.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
 - 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 3. Size: Factory or field cut to match requirements of supported equipment.
 - 4. Pad Material: Oil and water resistant with elastomeric properties.
 - 5. Surface Pattern: Waffle pattern.
 - 6. Infused nonwoven cotton or synthetic fibers.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
 - a. Surface Pattern: Smooth Ribbed or Waffle pattern.
 - b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- a. Housing: Cast-ductile iron or welded steel.
- b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.
 - 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 - 2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

2.6 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene
 - 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.7 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Mountings & Controls, Inc.
 - 2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 - 3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 RESTRAINT CHANNEL BRACINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Hilti, Inc.
 - 3. Mason Industries, Inc.
 - 4. Unistrut; Part of Atkore International.
- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.9 RESTRAINT CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Kinetics Noise Control, Inc.
 - 2. Loos & Co., Inc.
 - 3. Mason Industries, Inc.
 - 4. Vibration Mountings & Controls, Inc.
- B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.10 SEISMIC-RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Kinetics Noise Control, Inc.
 - 3. Mason Industries, Inc.
 - 4. TOLCO.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.11 MECHANICAL ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Hilti, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
- B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.12 ADHESIVE ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hilti, Inc.
 - 2. Kinetics Noise Control, Inc.
 - 3. Mason Industries, Inc.
- B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- D. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- E. Install cables so they do not bend across edges of adjacent equipment or building structure.
- F. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3.6 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.
- B. All identification means and procedures shall be fully coordinated with the facility. Follow established protocol, including but not limited to; equipment nomenclature, valve tag and piping color schemes, alpha/numeric identification, labeling, documentation, etc.. Follow the procedures herein described for specific items not addressed by the facilities.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

- A. Plastic Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.
 - d. Champion America.
 - e. Craftmark Pipe Markers.
 - f. emedco.
 - g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Marking Services, Inc.
 - j. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
 3. Letter Color: White
 4. Background Color: Black
 5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 8. Fasteners: Stainless-steel rivets or self-tapping screws.
 9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Carlton Industries, LP.
 4. Champion America.
 5. Craftmark Pipe Markers.
 6. emedco.
 7. LEM Products Inc.
 8. Marking Services Inc.
 9. National Marker Company.
 10. Seton Identification Products.
 11. Stranco, Inc.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: White
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Pipe Markers.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 2. Brady Corporation.
 3. Brimar Industries, Inc.
 4. Carlton Industries, LP.
 5. Champion America.
 6. Craftmark Pipe Markers.
 7. emedco.
 8. Kolbi Pipe Marker Co.
 9. LEM Products Inc.
 10. Marking Seivics Inc.
 11. Seton Identification Products.
- B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link chain or beaded chain or S-hook.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Carlton Industries, LP.
 4. Champion America.
 5. Craftmark Pipe Markers.
 6. emedco.
 7. Kolbi Pipe Marker Co.
 8. LEM Products Inc.
 9. Marking Seivics Inc.
 10. Seton Identification Products.

- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches minimum
 - 2. Fasteners: Brass grommet and wire or Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
 1. Low-Pressure Compressed Air Piping:
 - a. Background: Safety blue
 - b. Letter Colors: White
 2. Domestic Water Piping
 - a. Background: Safety green.
 - b. Letter Colors: White
 3. Sanitary Waste and Storm Drainage Piping:
 - a. Background Color: Safety black
 - b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches
 - b. Hot Water: 1-1/2 inches round
 - c. Low-Pressure Compressed Air: 1-1/2 inches round
 2. Valve-Tag Colors:
 - a. Cold Water: Safety green
 - b. Hot Water: Safety green
 - c. Low-Pressure Compressed Air: Safety blue
 3. Letter Colors:
 - a. Cold Water: White
 - b. Hot Water: White.
 - c. Low-Pressure Compressed Air: White.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 220553

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SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Roof drains and rainwater leaders.
 - 5. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
 - 2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. Products: Subject to compliance with requirements, provide one of the following:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perms at 43-mil dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: 60 percent by volume and 66 percent by weight.
 5. Color: White.

2.4 SEALANTS

- A. Joint Sealants:
- B. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F .
 5. Color: White.
 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: White.
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 - 2. Width: 3 inches.
 - 3. Thickness: 11.5 mils.
 - 4. Adhesion: 90 ounces force/inch in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch in width.
 - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

- 1. Products: Subject to compliance with requirements, provide one of the following:

- a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.

- 2. Width: 2 inches.
 - 3. Thickness: 6 mils.
 - 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - 5. Elongation: 500 percent.
 - 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.8 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Piping Enclosures:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGuire Manufacturing.
 - b. Truebro; a brand of IPS Corporation.
 - c. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
 - 2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as recommended by the manufacturer.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Keep insulation materials dry during application and finishing.
- F. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- G. Install insulation with least number of joints practical.
- H. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- I. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- J. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- K. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

- B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- C. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 - 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 - 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 - 7. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
 1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 1. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
- B. Insulation Installation on Pipe Flanges:
 1. Install preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, two locations of threaded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 thick.
- B. Domestic Hot and Recirculated Hot Water:
 - 1. Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type 1 inch thick.
 - 2. Stormwater and Overflow:
 - 3. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- C. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. Protective Shielding Piping Enclosures
- E. Floor Drains, Traps, and Sanitary Drain Piping Receiving Condensate and Equipment Drain Water below 60 Deg F :
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 - 1. None.
- C. Piping, Exposed:

In Mechanical Rooms, within 8 foot of the floor, public areas and areas visible to public view

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. PVC 20 mils thick.

END OF SECTION 220719

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. General Commissioning Requirements for Plumbing Systems and Equipment
 - 2. Plumbing Systems to be Commissioned

- B. Related Requirements:

- 1. Section 019113 "General Commissioning Requirements".
 - 2. Comply with all testing, start-up, installation, demonstration, and testing requirements in Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.3 DEFINITIONS

- A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- C. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.4 SUBMITTALS

- A. Action Submittals

- 1. Where required in Division 22 specifications; provide the CxA with actions submittals for all commissioned systems identified in this section.

- B. Informational Submittals

- 1. Pre-Functional Checklists, Start-Up Forms, and Test Reports: Where required in Division 22 specifications; provide the CxA material, installation, and performance test checklists for systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section. Note that Pre-Functional Checklists shall be completed prior to any Functional Performance Testing.

- C. IOM Manuals

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. The contractor shall provide the CxA with Installation and Operation Manuals of systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section

D. Closeout Submittals

1. Where required in Division 22 specifications; provide closeout submittals for all commissioned systems identified in this section.

1.5 QUALITY ASSURANCE

A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. Medical Gas Piping Systems Testing Technician Qualifications: Technicians to perform medical compressed-air, vacuum, and medical gas piping for laboratory and healthcare facilities system construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

C. Testing Equipment and Instrumentation Quality and Calibration:

1. Capable of testing and measuring performance within the specified acceptance criteria.
2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
3. Be maintained in good repair and operating condition throughout duration of use on Project.
4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Plumbing system proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SYSTEMS TO BE COMMISSIONED

- A. Central Laboratory Compressed Air System
 - 1. Air Compressor
 - 2. Pressure reducing stations
- B. Central Laboratory Vacuum System
 - 1. Vacuum Pump
- C. Central Deionized Water System
- D. Domestic Hot Water System
 - 1. Water Heaters
 - 2. Recirculation Pump System
 - 3. Mixing Valves
- E. Instrumentation and Controls associated with all of the above.

3.2 CX TESTING PREPARATION

- A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.
- B. Certify that plumbing systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.3 CX TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 CX TESTS COMMON TO PLUMBING

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 22 Sections specifying plumbing systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Construction checklist verification tests.
 - 2. Construction checklist verification test demonstrations.
 - 3. Cx tests.
 - 4. Cx test demonstrations.

END OF SECTION 220800

SECTION 221113 – FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes water-distribution piping and specialties outside the building for the following:
 - 1. Water services.
 - 2. Fire-service mains.

1.2 SUBMITTALS

- A. Product Data: For the following:
 - 1. Valves, piping and accessories.
 - 2. Fire hydrants.
 - 3. Fire department connections.
 - 4. Contractor shall submit a letter with product data certifying that all materials are in compliance with governing authority.
- B. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For the following:
 - 1. Valves.
 - 2. Backflow preventers.
 - 3. Protective enclosures.
 - 4. Hydrants.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with requirements of Missouri American Water Company.
 - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 - 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
 - 4. Comply with requirements of local fire district
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with requirements of governing jurisdiction for fire-service-main products, materials, installations, tests, flushing and all other activities and materials associated with installation.

1.4 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Construct Manager not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Construction Manager's written permission.

1.5 COORDINATION

- A. Coordinate connection to water main with Missouri American Water Company.
- B. Coordinate relocation of existing water main with Missouri American Water Company.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Available Products: Subject to compliance with requirements of the governing authority(s).
 - 2. Products: Subject to compliance with requirements of the governing authority(s).
 - 3. Manufacturers: Subject to compliance with requirements of the governing authority(s).

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 PIPE AND FITTINGS

- A. Regulatory Requirements (subject to requirements of governing jurisdiction):
 - 1. Comply with requirements of Missouri American Water Company

2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

2.4 JOINING MATERIALS

A. Regulatory Requirements (subject to requirements of governing jurisdiction):

1. Comply with requirements of Missouri American Water Company
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

2.5 VALVES

A. Regulatory Requirements (subject to requirements of governing jurisdiction):

1. Comply with requirements of Missouri American Water Company
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

2.6 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Regulatory Requirements (subject to requirements of governing jurisdiction):

1. Comply with requirements of Missouri American Water Company
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

- B. Indicator Posts:** UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve. Lockable.

2.7 BACKFLOW-PREVENTION DEVICES

A. Regulatory Requirements (subject to requirements of governing jurisdiction):

1. Comply with requirements of Missouri American Water Company

2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

2.8 FREESTANDING FIRE HYDRANTS

A. Regulatory Requirements (subject to requirements of governing jurisdiction):

1. Comply with requirements of Missouri American Water Company
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
4. Comply with requirements of local fire district where applicable

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Water-Main Connection: Tap water main according to requirements of Missouri American Water Company and of size and in location indicated.
- B. Comply with requirements of governing jurisdiction for fire-service-main piping materials and installation.
- C. Bury piping with depth of cover over top at least 42 inches (or as dictated by the governing jurisdiction if more stringent requirement), with top at least 12 inches below level of maximum frost penetration.
- D. Extend water-service piping and connect to water-supply source and building water piping systems at outside face of building wall in locations and pipe sizes indicated.
 1. Terminate water-service piping at building wall until building water piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building water piping systems when those systems are installed.

3.2 ANCHORAGE INSTALLATION

1. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches according to the requirements of the governing jurisdiction.

3.3 VALVE INSTALLATION

- A. Comply with the requirements of the governing jurisdiction for means and methods of installation for valves.

3.4 BACKFLOW-PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers with relief drain in vault or other space subject to flooding.

3.5 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position. Contractor shall comply with requirements of governing jurisdiction(s).

3.6 CONNECTIONS

- A. Piping installation requirements are specified in other Division 2 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect water-distribution piping to existing water main. Contractor to coordinate the tap with Missouri American Water Company.
- C. Connect water-distribution piping to interior domestic-water or fire-suppression piping; see drawings.
- D. Connect waste piping from drinking fountains to sanitary sewerage system. See Division 2 Section "Sanitary Sewerage" for connection to sanitary-sewer piping.

3.7 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Tests shall be conducted in accordance with the requirements of the governing authority(s).
- C. Prepare reports of testing activities.

3.8 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or as described below:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - c. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

1.5 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Architect, Construction Manager and Owner no fewer than five days in advance of proposed interruption of water service.
 - 2. Do not interrupt water service without Architect's, Construction Manager's and Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

- B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Copper Unions:
 - 1. MSS SP-123.
 - 2. Cast-copper-alloy, hexagonal-stock body.
 - 3. Ball-and-socket, metal-to-metal seating surfaces.
 - 4. Solder-joint or threaded ends.
- G. Appurtenances for Grooved-End Copper Tubing:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Shurjoint Piping Products.
 - b. Smith-Cooper International.
 - c. Star Pipe Products.
 - d. Victaulic Company.
 - 2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 copper tube or ASTM B 584 bronze castings.
 - 3. Mechanical Couplings for Grooved-End Copper Tubing:
 - a. Copper-tube dimensions and design similar to AWWA C606.
 - b. Ferrous housing sections.
 - c. EPDM-rubber gaskets suitable for hot and cold water.
 - d. Bolts and nuts.
 - e. Minimum Pressure Rating: 300 psig.

2.3 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe:
 - 1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Standard-Pattern, Mechanical-Joint Fittings:

Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01

1. AWWA C110/A21.10, ductile or gray iron.
 2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- C. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.
- D. Appurtenances for Grooved-End, Ductile-Iron Pipe:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Shurjoint Piping Products.
 - b. Smith-Cooper International.
 - c. Star Pipe Products.
 - d. Victaulic Company.
 2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions that match pipe.
 3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:
 - a. AWWA C606 for ductile-iron-pipe dimensions.
 - b. Ferrous housing sections.
 - c. EPDM-rubber gaskets suitable for hot and cold water.
 - d. Bolts and nuts.

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 TRANSITION FITTINGS

- A. General Requirements:
1. Same size as pipes to be joined.
 2. Pressure rating at least equal to pipes to be joined.
 3. End connections compatible with pipes to be joined.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Coupling: AWWA C219.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cascade Waterworks Mfg. Co.
 - b. Dresser, Inc.
 - c. Jay R. Smith Mfg. Co.
 - d. JCM Industries, Inc.
 - e. Romac Industries, Inc.
 - f. Smith-Blair, Inc.
 - g. Viking Johnson.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. HART Industrial Unions, LLC.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. Watts; a Watts Water Technologies company.
 - h. Wilkins.
 - i. Zurn Industries, LLC.
 - 2. Standard: ASSE 1079.
 - 3. Pressure Rating: 125 psig minimum at 180 deg F.
 - 4. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca.
 - d. Watts; a Watts Water Technologies company.
 - e. Wilkins.
 - f. Zurn Industries, LLC.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 125 psig minimum at 180 deg F.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
2. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig.
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elster Perfection Corporation.
 - b. Grinnell Mechanical Products.
 - c. Matco-Norca.
 - d. Precision Plumbing Products.
 - e. Victaulic Company.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."
- E. Install shutoff valve immediately upstream of each dielectric fitting.
- F. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- G. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- H. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- J. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- L. Install piping to permit valve servicing.
- M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- N. Install piping free of sags and bends.
- O. Install fittings for changes in direction and branch connections.
- P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- Q. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."
- R. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."

- S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
- G. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.
- H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- I. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges, flange kits or nipples.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.

- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 3. NPS 2: 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 - 3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

- b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
2. Piping Tests:
- a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

- 1. Close drain valves, hydrants, and hose bibbs.
- 2. Open shutoff valves to fully open position.
- 3. Open throttling valves to proper setting.
- 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
- 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.

6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge piping before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger , shall be the following:
 - 1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
- D. Under-building-slab, domestic water piping, NPS 2 and smaller shall be the following:
 - 1. Hard or soft copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
- E. Aboveground domestic water piping, NPS 2 and smaller, shall the following:
 - 1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and brazed or soldered joints.
- F. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L cast- or wrought-copper, solder-joint fittings; and brazed joints.
 - 2. Hard copper tube, ASTM B 88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.
- G. Aboveground, combined domestic water-service and fire-service-main piping, NPS 6 to NPS 12, shall be the following:
 - 1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly, ball, valves with flanged ends for piping NPS 2-1/2 and larger.
 - 2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
 - 3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure reducing valve.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Outlet boxes.
8. Hose stations.
9. Wall hydrants.
10. Drain valves.
11. Water-hammer arresters.
12. Air vents.
13. Trap-seal primer valves.
14. Specialty valves.
15. Flexible connectors.

B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 224500 "Emergency Plumbing Fixtures" for water tempering equipment.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.
 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Ames Fire & Waterworks.
 - c. Conbraco Industries, Inc.
 - d. FEBCO.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
- 2. Standard: ASSE 1001.
- 3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
- 4. Body: Bronze.
- 5. Inlet and Outlet Connections: Threaded.
- 6. Finish: Chrome plated.

- B. Hose-Connection Vacuum Breakers

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Legend Valve & Fitting, Inc.
 - c. MIFAB, Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Woodford Manufacturing Company.
 - f. Zurn Industries, LLC.
- 2. Standard: ASSE 1011.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3. Body: Bronze, non-removable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Chrome or nickel plated
6. Copy "Pressure Vacuum Breakers" Paragraph below and re-edit for each type of vacuum breaker required. If only one type is required, drawing designation may be omitted.

C. Pressure Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.
 - c. FEBCO.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig, through middle third of flow range.
 - a. Valves: Ball type, on inlet and outlet.

D. Laboratory-Faucet Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a Watts Water Technologies company.
 - c. Woodford Manufacturing Company.
 - d. Zurn Industries, LLC.
2. Standard: ASSE 1035.
3. Size: NPS 1/4 or NPS 3/8 matching faucet size.
4. Body: Bronze.
5. End Connections: Threaded.
6. Finish: Chrome plated.

E. Spill-Resistant Vacuum Breakers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a Watts Water Technologies company.
 - c. Zurn Industries, LLC.
2. Standard: ASSE 1056.
3. Operation: Continuous-pressure applications.
4. Size: As required
5. Accessories:

- a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.
 - c. FEBCO.
 - d. Flomatic Corporation.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle third of flow range.
5. Size: As indicated
6. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 and larger.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 3 and larger.
8. Configuration: Designed for horizontal, straight-through flow.
9. Accessories:
 - a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Hose-Connection Backflow Preventers

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a Watts Water Technologies company.
 - c. Woodford Manufacturing Company.
2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 1/2 or NPS 3/4.
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Honeywell International Inc.
 - c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig
4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.6 BALANCING VALVES

A. Memory-Stop Balancing Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Hammond Valve.
 - d. Jenkins Valves; Crane Energy Flow Solutions.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Red-White Valve Corporation.
 - h. Stockham; Crane Energy Flow Solutions.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Conbraco Industries, Inc.
 - c. Honeywell Water Controls.
 - d. Legend Valve & Fitting, Inc.
 - e. Leonard Valve Company.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- f. Powers.
 - g. Watts; a Watts Water Technologies company.
 - h. Zurn Industries, LLC.
 - 2. Standard: ASSE 1017.
 - 3. Pressure Rating: 125 psig.
 - 4. Type: Thermostatically controlled, water mixing valve.
 - 5. Material: Bronze body with corrosion-resistant interior components.
 - 6. Connections: Threaded inlets and outlet.
 - 7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
 - 8. Valve Finish: Chrome plated in public areas, Rough bronze in mechanical/service areas.
- B. Primary, Thermostatic, Water Mixing Valves
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.
 - d. Powers.
 - e. Zurn Industries, LLC.
 - 2. Standard: ASSE 1017.
 - 3. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 4. Type: Exposed-mounted or Cabinet-type, thermostatically controlled, water mixing valve.
 - 5. Material: Bronze body with corrosion-resistant interior components.
 - 6. Connections: Threaded union inlets and outlet.
 - 7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
 - 8. Valve Finish: Chrome plated.
 - 9. Piping Finish: Chrome plated.
 - 10. Cabinet: Factory fabricated, stainless steel, for recessed mounting and with hinged, stainless-steel door.
- C. Individual-Fixture, Water Tempering Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Honeywell Water Controls.
 - c. Lawler Manufacturing Company, Inc.
 - d. Leonard Valve Company.
 - e. Powers.
 - f. Watts; a Watts Water Technologies company.
 - g. Zurn Industries, LLC.
 - 2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
 - 3. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 4. Body: Bronze body with corrosion-resistant interior components.
 - 5. Temperature Control: Adjustable.

6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch
 - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch
 - c. Strainers NPS 5 and Larger: 0.10 inch 0.125 inch
6. Drain: Factory-installed, hose-end drain valve.

B. Icemaker Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company.
 - b. IPS Corporation.
 - c. LSP Products Group, Inc.
 - d. Oatey.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.9 HOSE BIBBS

A. Hose Bibbs

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral or field-installation, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Wheel handle.
14. Include operating key with each operating-key hose bibb.
15. Include[integral wall flange with each chrome- or nickel-plated hose bibb.

2.10 WALL HYDRANTS

A. Non-freeze Wall Hydrants

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Woodford Manufacturing Company.
 - g. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Rough bronze.
12. Operating Keys(s): Two with each wall hydrant.

2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Stop-and-Waste Drain Valves

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Jay R. Smith Mfg. Co.
 - c. Josam Company.
 - d. MIFAB, Inc.
 - e. Precision Plumbing Products.
 - f. Sioux Chief Manufacturing Company, Inc.
 - g. Tyler Pipe; a subsidiary of McWane Inc.
 - h. Watts; a Watts Water Technologies company.
 - i. Zurn Industries, LLC.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 1. Locate backflow preventers in same room as connected equipment or system.
 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 3. Do not install bypass piping around backflow preventers.
- B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- C. Install water-control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve and pump.
- G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."
- H. Install water-hammer arresters in water piping according to PDI-WH 201.
- I. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, according to authorities having jurisdiction and the device's reference standard.
 - 2. Provide inspection test and record report affixed to the assembly. Include a copy in the OEM.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 ADJUSTING

- A. Set field-adjustable flow set points of balancing valves.
- B. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221313 – FACILITY SANITARY SEWERS

PART 1 – GENERAL

1.1 SUMMARY

- A. All components of the sanitary sewer system shall be in accordance with Metropolitan St. Louis Sewer District (MSD) Standard Construction Specifications for sewers and drainage facilities, dated 2009 and here after referred to as MSD Standard Specifications.
- B. This Section includes gravity-flow, non-pressure sanitary sewerage outside the building, with the following components:
 - 1. Cleanouts.
 - 2. Pre-cast concrete manholes.
- B. Related Sections: The following sections contain requirements that relate to this Section.
 - 1. Division 31 Section "Earthwork" for excavating, backfilling and compacting operations required for sanitary sewer work.

1.2 SUBMITTALS

- A. Product Data: Submit complete materials list of items not covered by MSD standard specifications.
- C. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.
- C. Sanitary Sewer Record Drawings: Legibly mark drawings to record actual construction. Indicate horizontal and vertical locations, referenced to permanent surface improvements. Identify field changes of dimension and detail and changes made by change order.
- D. Certification: For all materials specified to comply with reference standards, submit Certificate of Compliance.

1.3 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of sanitary sewage system's products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Materials and methods of construction shall comply with the following standards.
 - 1. American Water Works Association, (AWWA).
 - 2. American Society for Testing and Materials, (ASTM).
 - 3. American Association of State Highway and Transportation Officials, (AASHTO).
 - 4. American Concrete Pipe Association, (ACPA).
 - 5. Metropolitan St. Louis Sewer District Standard Construction Specifications for Sewers and Drainage Facilities, 2009.
 - 6. Comply with all rules, regulations, or ordinances having jurisdiction over this work. In

absence of local codes, comply with the Uniform Plumbing Code.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle piping and accessories to prevent damage and deterioration. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Gasket materials and plastic materials shall be protected from exposure to the direct sunlight. Storage facilities for plastic pipe, fittings, joint materials and solvents shall be classified and marked in accordance with NFPA No. 704 with classification as indicated in NFPA No. 49 and NFPA No. 325M.

1.5 COORDINATION

- A. Coordinate locations and inverts of sanitary sewer lines at 5' outside building as noted on the plans.

1.6 PROJECT CONDITIONS

- A. Known underground and surface utility lines are indicated on the drawings. Contractor is responsible for verifying all utility locations shown or not shown.
- B. Protect existing trees, plant, lawns, and other features designated to remain as part of the landscape work.
- C. Barricade open excavations and post warning lights at work adjacent to public streets and walks.
- D. Promptly repair damage to adjacent facilities caused by sanitary sewer earthwork operations. Cost of repair at Contractor's expense.
- E. Promptly notify the owner's representative of unexpected sub-surface conditions.

1.7 COOPERATION

- A. Examine Drawings and Specifications for all Contracts to determine the nature of proposed construction. Perform work to conform with construction called for in such a manner as not to interfere or delay work of other Contractors.

PART 2 - PRODUCTS

2.1 PIPES AND PIPE FITTINGS:

- A. General: Provide pipes of one of the following materials, of weight/class indicated. Provide pipe fittings and accessories of same material and weight/class as pipes, with joining method as indicated.
- B. Gravity Sewer Piping:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. Polyvinyl Chloride (PVC) Pipe: ASTM D3034, Type PSM, SDR 35 (unless otherwise indicated)
2. Polyvinyl Chloride (PVC) Pipe AWWA C900, SDR 14: ASTM D1784 with Cells Class 12454,
3. Ductile Iron Pipe Class 52 as specified in the American National Standards Institute Specifications ANSI A21.51-86 (or latest revision) and the American Water Works Association AWWA C151 Standards.

C. Joints for Gravity Sewer Piping:

1. PVC SDR 35 Pipe: Elastomeric joints complying with ASTM D3212 using elastomeric seals complying with ASTM F477.
2. Polyvinyl Chloride (PVC) Pipe AWWA C900, Gaskets ASTM F477, Integral Bell Joint ASTM D3139
3. Ductile Iron Pipe Rubber Gasket Joints: All rubber gasket joints shall meet the standards for Ductile Iron and Gray Iron Pressure Pipe and Fittings as approved by the American National Standards Institute ANSI A21.11-85 (or latest revision) and the American Water Works Association AWWA C111 Standards.

D. Manholes and Cleanouts

1. In accordance with MSD standard specifications.

E. Frames and Covers: ASTM A48 gray cast-iron, asphalt coated, with lettering cast into top reading "SANITARY SEWER".

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated into the work include, but are not limited to, the following:
 - a. Neenah Foundry Co., Neenah, WI
 - b. McKinley Iron Works, Fort Worth, TX
 - c. Flockhart Foundry Co., Newark, NJ
3. Concrete Masonry Units: ASTM C139.
4. Manhole Brick: ASTM C32, Grade MS.
5. Precast Concrete Manhole Barrels and Cones: ASTM C478, 5" wall thickness with ASTM C443 "O" - ring gasket joints.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated into the work.
 - (1) See Quality Assurance section.
6. Mortar
 - a. Mortar for laying and parging concrete masonry: 1 part Portland cement and 2 parts sand.
 - b. Mortar for brickwork: 1 part Portland cement, 1/2 part hydrated lime, and 4-1/2 parts sand.
7. Manhole Rungs: cast-iron steps.

8. Manhole Drop Assembly: The vertical drop pipe and sweep shall be made from polyvinyl chloride (PVC) sewer pipe and fittings as specified herein. The fitting required for this work shall be molded PVC tees, plugs, and adapters. To the inside end of the tee, a threaded adapter shall be solvent welded, utilizing fresh solvent cement, made by the fittings manufacturer, containing at least 15 percent by weight of the same PVC compound used in making the fittings. Outside drop assemblies shall be encased in concrete as indicated on drawings.
9. Bedding Material: Clean, natural sand conforming to requirements in Section 02200 or minus-fraction crushed stone can be used.
10. Backfill Material: Backfill material shall adhere to the requirements of the local governing agency(s).
11. Pipe Connections: The precast reinforced concrete manhole sections shall be provided with circular openings at the locations and elevations for the proper connection of all pipes. Unless otherwise indicated, all PVC pipe connections shall be sealed with a flexible manhole seal assembly, per ASTM C-923. Flexible manhole seal assemblies shall permit at least an eight (8) degrees deflection from the centerline of the opening in any direction while maintaining a watertight connection.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Permits and Inspections: File all drawings and obtain all necessary permits, licenses, and inspections required by authorities having jurisdiction over the work.
- B. Layout sanitary sewer work and establish extent of excavation by area and elevation. Designate and identify datum elevation and project engineering reference points. Set required lines, levels and elevations.
- C. Do not cover or enclose work of this Section before obtaining required inspections, test approvals and location recording.

3.2 EXISTING UTILITIES

- A. Before starting excavation, establish the location and extent of underground utilities in the work area. Exercise care to protect existing utilities during earthwork operations. Perform excavation work near utilities by hand and provide necessary shoring, sheeting, and supports as work progresses.
- B. Protect active utility services uncovered by excavation.

3.3 HANDLING PIPE:

- A. Pipe and accessories shall be handled so as to insure delivery to the trench in sound, undamaged condition. Particular care shall be taken not to injure the pipe coating or lining. If the coating or lining of any pipe or fitting is damaged, the repair shall be made by the Contractor at his expense in a satisfactory manner. No other pipe or material of any kind shall be placed inside a pipe or fitting after the coating has been applied. Pipe shall be carried into position and not dragged. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the

trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material without additional expense to the Owner. Rubber gaskets that are not to be installed immediately shall be stored in a cool and dark place.

3.4 CUTTING OF PIPE:

- A. Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Cutting shall be done with an approved type mechanical cutter. Wheel cutter shall be used when practicable. Copper tubing shall be cut square and all burrs shall be removed. Squeeze type mechanical cutters shall not be used for ductile iron.

3.5 LOCATING SEWER LINES NEAR WATER LINES:

- A. Where the location of the sewer is not clearly defined by dimensions on the drawings, the sewer shall not be laid closer horizontally than 10 feet from the water pipe except where the bottom of the water pipe will be at least 18" above the top of the sewer pipe, in which case the sewer shall not be laid closer horizontally than 6 feet from the water pipe. Where gravity-flow sewers cross above water lines, the sewer pipe for a distance of at least 10 feet on each side of the crossing shall be fully encased in concrete or shall be made of pressure pipe. The minimum cover of the concrete encasement, including that at the pipe joints, shall not be less than 6" unless otherwise indicated on the drawings. Water and sanitary line crossings shall be at the mid points of full lengths of both pipes.

3.6 SEWER LINES AT STRUCTURES

- A. Where shown on the drawings, the sewer pipe shall be sleeved as required. Care shall be exercised and proper precautions taken during installation of the sewer pipe and sleeve to assure that there will be no damage to such structures and no settlement or movement of foundations or footings. Any damage occurring as a result of the Contractor's operation shall be corrected and all costs connected therewith shall be borne by the Contractor. When the sewer pipe location is within 3 feet of a proposed building, retaining wall, or structural foundation as stated above, the pipe shall be sleeved as required for an existing structure.

3.7 TRENCHING

- A. Perform excavating and backfilling as required to install sanitary sewer work. Excavation and backfill operations shall comply with the requirements of the local governing agency(s).
- B. Provide trench wall support and pumping of surface and ground water as required to provide suitable conditions for performing the work.
- C. Excavate trenches to accommodate indicated bedding conditions and material. Trim and shape trench bottoms to proper line and grade, free of irregularities. Remove unstable material and replace with compacted fill.

3.8 PLACING AND LAYING OF PIPE

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- A. Pipe shall be protected during handling against impact shocks and free fall and the pipe interior shall be free of extraneous material.
- B. Gravity Sewer Piping
 - 1. Pipe laying shall proceed upgrade with the spigot ends of bell-and-spigot pipe pointing in the direction of the flow. Each pipe shall be laid accurately to the line and grade shown on the drawing by use of a laser projector in the downstream manhole. Lay and fit pipe with sealed joints and full bearing in bedding material. Pipe shall be laid and centered so that the sewer has a uniform invert. As the work progresses, the interior of the sewer shall be cleared of all superfluous materials.
 - 2. Before making pipe joints, all surfaces of the portions of the pipe to be joined shall be clean and dry. Lubricants, and primers, shall be used as recommended by the pipe manufacturer. The joints shall then be placed, fitted, joined, and adjusted so as to obtain the degree of water tightness required.
 - 3. Installation of PVC pipe shall be installed in accordance with ASTM D2321 and ASTM F402, and all required precautions shall be taken to assure adequate trench ventilation and protection for workers installing the pipe.
- C. Trenches shall be kept free of water and as dry as possible during bedding, laying, and jointing and for as long a period as required. When work is not in progress, open ends of pipe and fittings shall be satisfactorily closed so that no trench water or other material will enter the pipe or fittings.
- D. Install pipe joint gaskets in accordance with manufacturer's recommendations.
- E. Cut pipe ends entering structures flush with inner face of structures.
- F. Extend sanitary sewer system as shown on drawings and make required connection.
- G. Backfill trenches to subgrade with suitable materials and per the compaction requirements as specified per the geotechnical report.
 - 1. Backfill evenly on both sides of piping for its full depth. Provide thorough compaction of fill under pipe haunches.
 - 2. Provide granular backfill of $\frac{3}{4}$ " minus crushed limestone and compacted to a minimum 95% of standard density (ASTM D-698 or AASHTO T-99-57). Use of clean rock will not be permitted.
- H. Mechanically compact backfill in accordance with the requirements of the geotechnical report. Water settling, puddling, and jetting as a compaction method are not acceptable.
- I. Fill, compact, and restore to subgrade level and condition all settlement.

3.9 TESTING

- A. General:
 - 1. The Contractor shall maintain his work site in a manner that will be fully accessible by the Owner's Representative for observation of the work.
 - 2. The Contractor shall conduct the leakage test promptly following installation of waste water pipe. This test shall include services that have been constructed.
 - 3. The Contractor shall notify the Owner's Representative 48 hours before conducting the

leakage test so that the Owner's Representative can schedule inspection and observation of the test.

4. The Contractor shall provide all equipment and conduct the test.

B. Plastic Pipe Deformation: In addition to leakage tests, a deformation test will be done as follows:

1. The test shall be conducted not less than one month (30 days) after backfill has been properly installed.
2. The maximum allowable deflection shall not exceed 5% of the pipe's internal diameter.
3. Mandrel testing shall be performed on 100% of the pipeline.
4. Mandrels shall be "Wortco 9-Arm Mandrel" (5% deflection) for flexible or semi-rigid pipe or approved equal.
5. Gauge shall be pulled through the pipe by hand. Mechanical pulling assistance is not permitted.
6. If any section of pipe does not conform to this requirement, it shall be replaced by the Contractor at no cost to the Owner. Leakage re-testing and mandrel re-testing shall take place 30 days after backfilling.

C. Leakage:

1. General:
 - a. Contractor shall clean pipe of excess mortar, joint sealant, and other dirt and debris prior to inspection.
 - b. Sewer will be inspected by flashing a light (lamping) between manholes and/or by physical passage where space permits.
 - c. The Owner's Representative will determine from illumination and/or physical inspection the presence of visible infiltration or other defects.
 - d. Defects shall be corrected prior to conducting leakage tests.
2. Leakage test shall be done either by a water exfiltration test or air exfiltration test.
 - a. For water tests, the allowable exfiltration shall be less than 0.15 gallons per inch of internal diameter per hour per 100' of pipe length (200 gallons per inch of ID per day per mile) per 24 hours.
 - b. For air exfiltration tests, the holding time shall not be less than that listed below:

TABLE 1

MINIMUM TIME REQUIRED FOR A 1.0 psig PRESSURE DROP FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015 (CFM/SF INTERNAL SURFACE AREA)

Pipe Diameter (in.)	Minimum Time, (min:sec)	Length for Minimum Time, (ft)	Time for Longer Length, (sec)	Specification Time for Length (L) Shown, (min:sec)							
				100 ft.	150 ft.	200 ft.	250 ft.	300 ft.	350 ft.	400 ft.	450 ft.
6	5:40	398	0.854L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

8	7:34	298	1.520L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48

- c. The Contractor may use air exfiltration testing for pipes of all sizes.
 - d. The Contractor shall perform water exfiltration tests on manholes and may perform water exfiltration tests on sewer pipe larger than 18" ID.
3. Any sections of pipe not meeting the test requirements shall be repaired and the test shall be repeated until work is acceptable.
- a. The Contractor is encouraged to pretest the pipes prior to notifying the Owner's Representative and formal testing.
 - b. For any section of pipe not passing the test when requested by the Contractor, the Contractor shall be responsible for the total cost of re-inspection. The Owner reserves the right to deduct the cost of re-inspection from the Contractor's payment for the work.

D. Exfiltration Test (Water)

1. The Contractor shall furnish all labor, equipment, tools, and materials required including bulkheads, water, and all miscellaneous items required to perform the test.
2. Perform all tests for lines at a minimum water depth 2' above the high point of the system or 2' above ground water elevation, whichever is higher. Perform tests at a minimum water depth of 2' above casting elevation for manholes.
3. Tests shall be maintained to locate all leaks, but not less than two hours. Measurement of exfiltration amounts shall be confirmed by the Owner's Representative.
4. Tests shall be repeated after repair of leaks and defects, until leakage meets the requirements of this specification.
5. Manholes and other structures shall be protected by means of bulkheads to prevent bursting pressure from being applied inside the structure.
6. Pipe shall be de-watered upon completion of the successful test.

E. Exfiltration Test (Air)

1. In the areas where ground water is known to exist, the Contractor shall install a 1/2" diameter capped pipe nipple approximately 10" long through the manhole wall on top of one of the sewer lines entering the manhole.
 - a. Install at the time the sewer line is installed.
 - b. Immediately prior to performance of the line acceptance test, the ground water level shall be determined by removing the pipe cap, blowing air through the pipe nipple into the ground to clear it, and then connecting a clear plastic tube to pipe nipple.
 - c. The hose shall be held vertically and measurement of height of water, in feet, shall be taken after the water stops rising in this plastic tube.
 - d. The height shall be divided by 2.3 to establish the pounds of pressure that will be

added to all readings.

2. Contractor shall furnish all facilities required including necessary piping connections, test pumping equipment, pressure gauges, bulkheads, regulators to avoid over-pressurization, and all miscellaneous items required.
 - a. The pipe plug for introducing air to the sewer pipe shall be equipped with two taps. One tap will be used to introduce air into the line being tested, through suitable valves and fittings, so that the input air may be regulated. The second tap will be fitted with valves and fittings to accept a pressure test gauge indicating internal pressure in the sewer pipe. An additional valve and fitting will be incorporated on the tap used to check internal pressures so that a second test gauge may be attached to the internal pressure tap. Pressure test gauge will also be used to indicate loss of air pressure due to leaks in the sewer line.
 - b. The pressure test gauge shall meet the following minimum specifications: Size (diameter)--4-1/2"; Pressure Range -- 0 to 15 psi; Figure Intervals 1 psi increments; Minor Subdivisions -- 0.05 psi; pressure Tube Bourdon 2 or diaphragm; Accuracy -- +/- 0.25% of maximum scale reading; Dial white coated aluminum with black lettering, 2700 arc and mirror edge; Pipe Connection - low male, 1/2" NPT.
 - c. Calibration data will be supplied with all pressure test gauges. Certification of pressure test gauge will be required from the gauge manufacturer. This certification and calibration data will be available to the Owner's Representative whenever air tests are performed.
 3. Test each reach of sewer pipe between manholes at the completion of the installation of pipe and appurtenances and the backfill of the sewer trench.
 4. Plug ends of line, cap or plug all connections to withstand internal pressure. One of the plugs provided must have two taps for connecting equipment.
 - a. After connecting air control equipment to air hose, monitor air pressure so that the internal pressure does not exceed 5 psig.
 - b. After reaching 4 psig, throttle the air supply to maintain between 4 and 3.5 psig for at least two minutes in order to allow equilibrium between air temperature and pipe walls. During this time, check all plugs to detect any leakage.
 - c. If plugs are found to leak, bleed off air, tighten plugs, and re-pressurize. After the temperature has stabilized, the pressure is allowed to decrease to 3.5 psig.
 - d. At 3.5 psig, begin timing to determine the time required for the air pressure to drop to 2.5 psig. If the time in seconds for the air pressure to decrease from 3.5 psig to 2.5 psig is greater than the time shown in Table 1 in this section, the pipe shall be presumed free of defects.
- F. If the air test fails to meet the above requirements, repeat test as necessary after all leaks and defects have been repaired. Prior to acceptance, all constructed sewer lines shall satisfactorily pass the low pressure air test or the exfiltration test.

3.10 REPAIRS TO BROKEN PIPE:

- A. Where cracks or ruptures develop in the pipe after installation, the entire length of pipe to a distance of at least 3 feet beyond the pipe joint on each side of the damage area shall be re-excavated. The pipe shall be replaced, or if approved by the Construct Manager, shall be repaired in a suitable manner. Details of repairs shall be submitted for record. If the Contractor utilizes concrete cradle or encasement in his repair, he shall take precautions to guard against shear breaks at the limits of the

concrete. Repaired sections shall be re-inspected approximately 6 months after completion of the repair. Should additional failures be noted, they shall be promptly repaired and later re-

- B.
- C.
- D. inspected as approved and at no additional cost to the Owner.

3.11 MANHOLE STRUCTURES

A. Precast Concrete Manholes

1. Place precast concrete manhole sections as indicated. Where manholes occur in pavements, set tops of frames and covers flush with finish surface. Elsewhere, set tops 3" above finish surface, unless otherwise indicated.

- a. Install in accordance with MSD standard specifications.
- b. Install in accordance with ASTM C891.
- c. Provide rubber joint gasket complying with ASTM C443 at joints of sections.
- d. Apply bituminous mastic coating at joints of sections.

- B. Construct flow channels with concrete or brick, conforming to the inside diameter of connecting lines. Make changes in grade gradually and make changes in line with true curves.
- C. Set frames and covers to required grade and bed in place with mortar.
- D. Cold weather protection: Provide all necessary means for heating concrete, masonry materials, and mortar to protect concrete and masonry work during and after installation from damage by frost and freezing.
- E. Perform no work when the temperature is below 25 degrees F. (ambient)

3.12 CLEANOUTS

- A. Furnish and install where shown on Drawings all exterior cleanouts extended to finished grade, with solid cover, of size indicated on Drawings. Where cleanouts occur in lawn area, provide concrete collar per detail.

3.13 CONNECTIONS TO EXISTING MANHOLES:

- A. Pipe connections to existing manholes shall be made in such manner that the finished work will conform as nearly as practicable to the essential applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping.

3.14 BUILDING CONNECTIONS:

- A. Shall include the lines to and connection with the building waste drainage piping at a point approximately 5 feet outside the building, unless otherwise indicated. Where building drain piping is not installed, the contractor shall terminate the building connections approximately 5 feet from the site of the building at a point as shown on the plans.

3.15 TAP CONNECTIONS:

- A. Make connections to existing piping and underground structures, so that finished work will conform as nearly as practicable to requirements specified for new work.
- B. For branch connections from side into existing 24" or larger pipe or to underground structures, cut opening into unit sufficiently large to allow 3" of concrete to be placed around entering connection. Cut ends of connection passing through pipe or structure wall to conform to shape of, and be flush with, inside wall, unless otherwise indicated. On outside of pipe or structure wall, encase entering connection in 6" of concrete for a minimum length of 12 to provide additional support or collar from connection to undisturbed ground.
 - 1. Provide concrete which will attain minimum 28-day compressive strength of 3,000 psi unless otherwise indicated.
 - 2. Use epoxy bonding compound as interface between new and existing concrete and piping materials.
- C. Take care while making tap connections to prevent concrete or debris from entering existing piping or structure. Remove debris, concrete, or other extraneous material which may accumulate.

3.19 CLOSING ABANDONED UTILITIES:

- A. Close open ends of abandoned underground utilities which are indicated to remain in place. Provide sufficiently strong closures to withstand hydro-static or earth pressure which may result after ends of abandoned utilities have been closed.
 - 1. Close open ends of concrete or masonry utilities with not less than 8" thick brick masonry bulkheads.
 - 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods for size and type material being closed. Wood plugs are not acceptable.

3.20 DISPOSAL OF WASTE MATERIALS

- A. Stockpile, haul from site and legally dispose of waste materials, including excess excavated materials, rock, trash, and debris.
- B. Maintain disposal route clear, clean, and free of debris.

3.21 CLEANING

- A. Maintain sanitary sewer piping and structures in a clean workable condition during construction operations.
- B. Flush sanitary sewer system with water in sufficient volume to obtain free flow through each line. Remove all silt, trash, and debris just prior to acceptance of work by Owner.
- C. Upon completion of sanitary sewer work, remove tools and equipment. Provide site clear, clean, free of debris, and suitable for site work operations.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

END OF SECTION 221313

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipe, tube, and fittings.
 - 2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.
 - 2. Waste, Force-Main Piping: 100 psig.
- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
1. Notify Architect, Construction Manager and Owner no fewer than five days in advance of proposed interruption of sanitary waste service.
 2. Do not proceed with interruption of sanitary waste service without Architect, Construction Manager and Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Charlotte Pipe and Foundry Company.
 - c. MIFAB, Inc.
 - d. Mission Rubber Company, LLC; a division of MCP Industries.
 - e. Tyler Pipe; a subsidiary of McWane Inc.
 2. Standards: ASTM C 1277 and ASTM C 1540.

3. Description: Heavy duty stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

- A. Solid-Core PVC Pipe: ASTM F 1785, Schedule 40.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- C. Adhesive Primer: ASTM F 656.
 1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. Solvent Cement: ASTM D 2564.
 1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
 2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 3. Shielded, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company, LLC; a division of MCP Industries.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- L. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants,

cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

- M. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Sanitary Drain: 2 percent downward in direction of flow for piping NPS 2-1/2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- O. Install piping according to applicable plumbing code.
- P. Install piping according to ASME A112.3.1 and applicable plumbing code.
- Q. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- R. Install underground PVC piping according to ASTM D 2321.
- S. Plumbing Specialties:
 - 1. Install backwater valves in sanitary waster gravity-flow piping. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."
- T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- C. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- D. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in OD's.
 - 2. In Drainage Piping: Shielded, non-pressure transition couplings.
 - 3. In Aboveground Force Main Piping: Fitting-type transition couplings.
- B. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
 - 2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
 - 3. Install backwater valves in accessible locations.
 - 4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.

2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
 4. Install individual, straight, horizontal piping runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 5. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 5. NPS 6: 10 feet with 5/8-inch rod.
- I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.
- 3.6 CONNECTIONS
- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 5. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
 6. Comply with requirements for backwater valves, cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
 7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.9 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
 1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.
 2. Copper DWV tube, copper drainage fittings, and soldered joints..
 3. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- C. Aboveground, soil and waste piping NPS 5 and larger shall be the following:
 1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.
 2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- D. Aboveground, vent piping NPS 4 and smaller shall be any of the following:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 2. Copper DWV tube, copper drainage fittings, and soldered joints.
 - a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- E. Aboveground, vent piping NPS 5 and larger shall be the following:
1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- F. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; cast-iron hubless-piping couplings; and coupled joints.
 2. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- G. Underground, soil and waste piping NPS 5 and larger shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; cast-iron hubless-piping couplings; coupled joints.
 2. Solid-wall PVC pipe; PVC socket fittings; and solvent-cemented joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- H. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 2. Galvanized-steel pipe, pressure fittings, and threaded joints.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Backwater valves.
- 2. Cleanouts.
- 3. Floor drains.
- 4. Roof flashing assemblies.
- 5. Through-penetration firestop assemblies.
- 6. Miscellaneous sanitary drainage piping specialties.
- 7. Flashing materials.
- 8. Solids interceptors.

- B. Related Requirements:

- 1. Section 221423 "Storm Drainage Piping Specialties" for storm drainage piping inside the building, drainage piping specialties, and drains.

1.3 INFORMATIONAL SUBMITTALS

- 1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- 2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.2 CLEANOUTS

A. Exposed Metal Cleanouts

1. ASME A112.36.2M, Cast-Iron Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg. Co.
 - 2) Josam Company.
 - 3) MIFAB, Inc.
 - 4) Tyler Pipe; a subsidiary of McWane Inc.
 - 5) Watts; a Watts Water Technologies company.
 - 6) Zurn Industries, LLC.

B. Metal Floor Cleanouts:

1. ASME A112.36.2M, Cast-Iron Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg. Co.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

- 2) Josam Company.
 - 3) Sioux Chief Manufacturing Company, Inc.
 - 4) Tyler Pipe; a subsidiary of McWane Inc.
 - 5) Watts; a Watts Water Technologies company.
 - 6) Zurn Industries, LLC.
2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule, heavy-duty, adjustable housing or threaded, adjustable housing] cleanout.
 3. Size: Same as connected branch.
 4. Type: Adjustable housing, Cast-iron soil pipe with cast-iron ferrule, Heavy-duty, adjustable housing or Threaded, adjustable housing.
 5. Body or Ferrule: Cast iron.
 6. Clamping Device: Required.
 7. Outlet Connection: Spigot or Threaded.
 8. Closure: Brass plug with straight threads and gasket.
 9. Adjustable Housing Material: Cast iron with threads or set-screws or other device.
 10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy and rough bronze finish
 11. Frame and Cover Shape: Round.
 12. Top Loading Classification: Medium Duty.
 13. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.
 14. Standard: ASME A112.3.1.
 15. Size: Same as connected branch.

C. Cast-Iron Wall Cleanouts

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
2. Standard: ASME A112.6.3.
3. Pattern: as scheduled
4. Body Material: Gray iron
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Coating on Interior and Exposed Exterior Surfaces: as scheduled
10. Sediment Bucket: as scheduled.
11. Top of Body and Strainer Finish: as scheduled.
12. Top Shape: Round.
13. Dimensions of Top or Strainer: as scheduled.
14. Trap Material: Cast iron.
15. Trap Pattern: Deep-seal P-trap.
16. Trap Features: Trap-seal primer valve drain connection

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company.
 - b. Thaler Metal Industries Ltd.
 - c. Zurn Industries, LLC.
2. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 10 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
 - a. Open-Top Vent Cap: Without cap.
 - b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
 - c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.

3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping[with increaser fitting of size indicated.

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
 - a. NPS 2: 4-inch-minimum water seal.
 - b. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings :

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Expansion Joints :

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.7 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
1. General Applications: 12 oz./sq. ft..
 2. Vent Pipe Flashing: 8 oz./sq. ft..
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.
- G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.8 SOLIDS INTERCEPTORS

A. Solids Interceptors:

1. Cast-Iron or Steel Solids Interceptors:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg. Co.
 - 2) Josam Company.
 - 3) MIFAB, Inc.
 - 4) Tyler Pipe; a subsidiary of McWane Inc.
 - 5) Watts; a Watts Water Technologies company.
 - 6) Zurn Industries, LLC.

2. Type: Factory-fabricated interceptor made for removing and retaining sediment from wastewater.
3. Body Material: Cast iron or steel
4. Interior Separation Device: Basket.
5. Interior Lining: Corrosion-resistant enamel.
6. Exterior Coating: Corrosion-resistant enamel
7. End Connections: No-Hub or Threaded
8. Mounting: Inline.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

- F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- H. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
- I. Assemble open drain fittings and install with top of hub 1 inch above floor.
- J. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- K. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- L. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- O. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.
- P. Install wood-blocking reinforcement for wall-mounting-type specialties.
- Q. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Copper Sheets: Solder joints of copper sheets.

- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

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SECTION 221323 - SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sand interceptors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
- B. Shop Drawings: For each type and size of precast-concrete interceptor indicated.
 - 1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from Installers of the items involved:
 - 1. Interceptors.
 - 2. Piping connections. Include size, location, and elevation of each.
 - 3. Interface with underground structures and utility services.

PART 2 - PRODUCTS

2.1 SAND INTERCEPTORS

- A. Description: Factory-fabricated, cast-iron or steel body and inlet grate; with settlement chamber and removable basket or strainer.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. Jay R. Smith Mfg. Co.
 2. MIFAB, Inc.
 3. Tyler Pipe; a subsidiary of McWane Inc.
 4. Zurn Industries, LLC.
- C. Outlet Piping Connection: Hub, hubless, or threaded, unless otherwise indicated.
- D. Grate: Cast iron or steel with reinforcement to provide ASTM C 890, A-03, walkway load.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION

- A. Set tops of grating frames and grates flush with finished surface.
- B. Set interceptors level and plumb.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make piping connections between interceptors and piping systems.
1. Use warning tapes or detectable warning tape over ferrous piping.
 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION 221323

SECTION 221413 – FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. All components of the storm drainage system shall be in accordance with Metropolitan St. Louis Sewer District (MSD) Standard Construction Specifications for sewers and drainage facilities, dated 2009 and here after referred to as MSD Standard Specifications.
- B. This Section includes gravity-flow, non-pressure storm drainage outside the building, with the following components:
 - 1. Cleanouts.
 - 2. Pre-cast concrete structures.
 - 3. Pre-cast concrete, metal and plastic pipe.
 - 4. Plastic Yard Drains

1.2 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, Non-pressure, Drainage-Piping Pressure Rating: 10-foot head of water.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, within MSD standard specifications.

2.2 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.3 STEEL PIPE AND FITTINGS

- A. Corrugated-Steel Pipe and Fittings: ASTM A 760, Type I with fittings of similar form and construction as pipe.
 - 1. Standard-Joint Bands: Corrugated steel.
 - 2. Coating: Aluminum or Zinc.

2.4 CONCRETE PIPE AND FITTINGS

- A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, with bell-and-spigot ends and gasketed joints with ASTM C 443, rubber gaskets.

1. Class III, Wall B.

2.5 PE PIPE AND FITTINGS

- A. Corrugated PE Drainage Pipe and Fittings NPS 10 and Smaller: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
3. Piping in subparagraph below is available in NPS 12 to NPS 48 (DN 300 to DN 1200). Joints are coupling type.

- B. Corrugated PE Pipe and Fittings NPS 12 to NPS 48: AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Joints made using couplings in subparagraph below are soiltight.
3. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

- C. Corrugated PE Pipe and Fittings NPS 56 and NPS 60: AASHTO MP7, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO MP7, corrugated, matching pipe and fittings.

2.6 PVC PIPE AND FITTINGS

- A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM D 3212, elastomeric seals.

- B. Polyvinyl Chloride (PVC) Pipe AWWA C900, SDR 14: ASTM D1784 with Cells Class 12454, , Gaskets ASTM F477, Integral Bell Joint ASTM D3139

2.7 CLEANOUTS

- A. PVC Cleanouts as shown on drawings.

1. Top-Loading Classification(s): Heavy duty.
2. Sewer Pipe Fitting and Riser to Cleanout: ASTM D 3034, PVC pipe.

2.8 SEWER STRUCTURES

- A. Standard Pre-cast Concrete Manholes: In accordance with MSD standard specifications and ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 - 1. Diameter: 42 inches minimum, unless otherwise indicated.
 - 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 - 3. Base Section: 6-inch minimum thickness for floor slab and 6-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 - 4. Riser Sections: 6-inch minimum thickness, and of length to provide depth indicated.
 - 5. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 - 6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 - 7. Steps: In accordance with MSD Standards; see Sheet 58 of standard specs.
 - 8. Grade Rings: Reinforced concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
 - 9. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch-diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
 - a. Material: ASTM A 48, Class 30B cast iron, unless otherwise indicated.
- B. Frames and Grates: In accordance with MSD Standard specs, Sheet 48.
- C. Plastic Yard Drains
 - 1. 18-inch 1-piece Catch Basin
 - a. Color: Black
 - 2. 8-inch Catch Basin Riser
 - a. Color: Black
 - 3. 18-inch by 18 inch Square Grate
 - a. Structural-foam polyolefin grate with UV inhibitor.
 - b. Inlet capacity: 136 gpm
 - c. Load: 175 psi max.
 - d. Color: green

2.9 CONCRETE

- A. General: Cast-in-place concrete in accordance with MSD standard specifications and according to ACI 318/318R, ACI 350R, and the following:
 - 1. Cement: ASTM C 150, Type II.
 - 2. Fine Aggregate: ASTM C 33, sand.
 - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 - 4. Water: Potable.

- B. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water-cement ratio.
 - 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 - 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Pipe couplings and fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
 - 1. Use non-pressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.
 - a. Unshielded flexible couplings for same or minor difference OD pipes.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 - 2. NPS 8 to NPS 15: PVC sewer pipe and fittings, gaskets, and gasketed joints.

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Installation in accordance with MSD standard specifications.
- C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- D. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- E. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- F. Install gravity-flow, non-pressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
 - 2. Install piping with 36-inch minimum cover.
 - 3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 - 4. Install RCP in accordance with MSD Standard specs.

- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses.

3.3 PIPE JOINT CONSTRUCTION

- A. Basic pipe joint construction in accordance with MSD standard specifications.

3.4 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use PVC pipe fittings in sewer pipes at branches for cleanouts and PVC pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 1. Use heavy-duty, top-loading classification cleanouts.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block as shown on drawings. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.5 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install manholes and structures in accordance with MSD standard specifications.
- C. Install pre-cast concrete manhole sections with sealants according to ASTM C 891.
- D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.6 CONNECTIONS

- A. Connect non-pressure, gravity-flow drainage piping to building's storm building drains specified in Division 15 Section "Storm Drainage Piping."
- B. Make connections to existing piping in accordance with MSD standard specifications.

3.7 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate report for each system inspection in accordance with MSD standard specifications.
 - 2. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - 3. Re-inspect and repeat procedure until results are satisfactory.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects in accordance with MSD standard specifications.
- C. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.
 - 4. Backwater valves.
 - 5. Through-penetration firestop assemblies.
 - 6. Flashing materials.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
 - 2. Standard: ASME A112.6.4, for general-purpose roof drains.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3. Body Material: Cast iron.
4. Dimension of Body: Nominal 14-inch diameter.
5. Combination Flashing Ring and Gravel Stop: Required.
6. Flow-Control Weirs: Not required.
7. Outlet: Bottom.
8. Extension Collars: As Required.
9. Underdeck Clamp: Required.
10. Expansion Joint: Required.
11. Sump Receiver Plate: Required.
12. Dome Material: Aluminum or Cast iron.
13. Perforated Gravel Guard: Not required.
14. Vandal-Proof Dome: Required.
15. Water Dam: As Required.

B. Metal, Large-Sump, Promenade Roof Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
2. Standard: ASME A112.6.4, for promenade roof drains.
3. Body Material: Cast iron.
4. Dimension of Body: Nominal 14-inch diameter.
5. Dimension of Frame and Grate: 14 inches square.
6. Outlet: Bottom.
7. Grate Material: Cast iron.
8. Vandal-Proof Grate: Required.
9. Extension Collars: As Required.
10. Underdeck Clamp: Required.
11. Expansion Joint: As Required.
12. Sump Receiver Plate: Required.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:

1. Description: Stainless body with inlet and wall flange with mounting holes.
2. Size: Same as connected conductor.

B. Test Tees:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
 3. Size: Same as connected drainage piping.
 4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
 5. Closure Plug: Countersunk or raised head, brass.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ProSet Systems Inc.
2. Standard: ASTM E 814, for through-penetration firestop assemblies.
3. Certification and Listing: Intertek Testing Service NA or testing agency acceptable to authorities having jurisdiction for through-penetration firestop assemblies.
4. Size: Same as connected pipe.
5. Sleeve: steel or cast iron, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.4 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft..
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 - 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - 2. Install expansion joints, if indicated, in roof drain outlets.
 - 3. Position roof drains for easy access and maintenance.
- B. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- C. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate cleanouts at base of each vertical soil and waste stack.
- D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- F. Install test tees in vertical conductors and near floor.
- G. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

- H. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.
- I. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

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SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Submersible sump pumps.
 - 2. Wet-pit-volute sump pumps.
 - 3. Sump-pump basins and basin covers.
 - 4. Packaged drainage-pump units.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.[Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.

- C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 WET-PIT-VOLUTE SUMP PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Pumps, Inc.
 - 2. Federal
 - 3. Flo Fab inc.
 - 4. PACO Pumps; Grundfos Pumps Corporation, USA.
 - 5. Peerless Pump Company.
 - 6. Pentair Pump Group.
 - 7. Weil Pump Company, Inc.
- B. Description: Factory-assembled and -tested sump-pump unit.
- C. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
- D. Pump Casing: Cast iron, with strainer inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.
- E. Impeller: Statically and dynamically balanced ASTM B 584, cast bronze, semi open design for clear wastewater handling, and keyed and secured to shaft.
- F. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
- G. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
- H. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray iron threaded fittings.
- I. Support Plate: Cast iron or coated steel and strong enough to support pumps, motors, and controls. Refer to Part 2 "Sump-Pump Basins and Basin Covers" Article for requirements.
- J. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
- K. Motor: Single-speed; grease-lubricated ball bearings and mounting on vertical, cast-iron pedestal.
- L. Controls:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Enclosure: NEMA 250, Type 4X; wall-mounted.
2. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

M. Control-Interface Features:

1. Remote Alarm Contacts: For remote alarm interface.
2. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - a. On-off status of pump.
 - b. Alarm status.

2.2 SUMP PUMP CAPACITIES AND CHARACTERISTICS

- A. Unit Capacity: 700 gpm.
- B. Number of Pumps: Two.
- C. Each Pump:
 1. Capacity: 350 gpm.
 2. Total Dynamic Head: 25 feet.
 3. Speed: 1750.
 4. Discharge Size: 4 inch NPS.
 5. Electrical Characteristics:
 - a. Motor Horsepower: 5 HP.
 - b. Volts: 480.
 - c. Phases: Three.
 - d. Hertz: 60.

2.3 SUMP-PUMP BASINS AND BASIN COVERS

- A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
 1. Material: Reinforced fiberglass or polyethylene.
 2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
 3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
- B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.
2. Cover Material: Cast iron.
3. Cover Diameter: Not less than outside diameter of basin top flange.
4. Manhole Required in Cover: Yes.
5. Vent Size: 2 inch NPS.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation and filling are specified in Section 312000 "Earth Moving."

3.2 EXAMINATION

- A. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

3.3 INSTALLATION

- A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Provide all printed materials in the OEM and on CD/DVD.
3. Provide video recording of session.

3.7 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

B. Provide all printed materials in the OEM and on CD/DVD.

C. Provide video recording of session.

END OF SECTION 221429

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SECTION 223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1, Section 7, "Service Water Heating."
- C. Shop Drawings:
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

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Webster University
Canon Design Project No. 004561.01**

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of commercial, gas-fired, domestic-water heater, from manufacturer.
- C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.
- C. ASME Compliance:
1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Burner: Five years.
 - 3) Controls and Other Components: Five years.
 - 4) Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bradford White Corporation.
 - b. Lochinvar, LLC.
 - c. PVI Industries, LLC.
 - d. Rheem Manufacturing Company.
 - e. Smith, A. O. Corporation.
 - f. State Industries.
2. Standard: ANSI Z21.10.3/CSA 4.3.
3. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
4. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - b. Lining: Glass complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
- g. Temperature Control: Adjustable thermostat.
- h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Honeywell Water Controls.
 - c. Smith, A. O. Corporation.
 - d. State Industries.
 - e. Taco, Inc.
- 2. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
- 3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
- 4. Capacity and Characteristics:
 - a. Working-Pressure Rating: 150 psig.
 - b. Capacity Acceptable: 26 gallon volume, 17 gallon acceptance, minimum.
 - c. Air Precharge Pressure: 40 PSI

B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

C. Heat-Trap Fittings: ASHRAE 90.2.

D. Comply with requirements for ball shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13.

- 1. Comply with requirements for balancing valves specified in Section 221119 "Domestic Water Piping Specialties."

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- E. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

- 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.

- F. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 6. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 7. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping,".

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

- C. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- D. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping."
- E. Drawings indicate general arrangement of piping, fittings, and specialties.
- F. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.2 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain[commercial, gas-fired, storage, domestic-water heaters.
- B. Provide all printed materials in the OEM and on CD/DVD.
- C. Provide video recording of session.

END OF SECTION 223400

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Water closets.
 - 2. Flushometer valves.
 - 3. Toilet seats.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite WE 1 and Credit WE 3: Documentation indicating flow and water consumption requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Two of each type installed.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

A. Water Closets: Wall mounted, top spud, accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard America.
 - b. Kohler Co.
 - c. TOTO USA, INC.
2. Bowl:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Siphon jet.
 - d. Style: Flushometer valve.
 - e. Height: Standard.
 - f. Rim Contour: Elongated.
 - g. Water Consumption: 1.1 gal. per flush.
 - h. Spud Size and Location: NPS 1-1/2; top.
3. Support:
 - a. Standard: ASME A112.6.1M.
 - b. Description: Waste-fitting assembly as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
 - c. Water-Closet Mounting Height: Standard, and Handicapped/elderly according to ICC/ANSI A117.1.

2.2 FLUSHOMETER VALVES

A. Battery-Powered, Solenoid-Actuator, Piston Flushometer Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Co.
 - b. Moen Commercial.
 - c. Sloan Valve Company.
 - d. TOTO USA, INC.
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

7. Style: Exposed.
8. Trip Mechanism: Battery-powered electronic sensor complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
9. Consumption: 1.1 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard America.
 - b. Bemis Manufacturing Company.
 - c. Centoco Manufacturing Corporation.
 - d. Church Seats; Bemis Manufacturing Company.
 - e. Kohler Co.
 - f. Olsonite Seat Co.
 - g. TOTO USA, INC.
2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial Heavy duty.
5. Shape: Elongated rim, open front.
6. Hinge: Self-sustaining, check.
7. Hinge Material: Stainless steel.
8. Seat Cover: Not required.
9. Color: White
10. Protection: antimicrobial.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.
- B. Examine walls and floors for suitable conditions where water closets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.
5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

3.4 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

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SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Urinals.
 - 2. Flushometer valves.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for urinals.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite WE 1 and Credit WE 3: Documentation indicating flow and water consumption requirements.
- C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: two of each type installed.

PART 2 - PRODUCTS

A. Urinals: Wall hung, back outlet, washout, accessible.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard America.
 - b. Kohler Co.
 - c. TOTO USA, INC.
2. Fixture:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Washout with extended shields.
 - d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
 - e. Water Consumption: Low.
 - f. Spud Size and Location: NPS 3/4, top.
 - g. Outlet Size and Location: NPS 2, back.
 - h. Color: White.
3. Waste Fitting:
 - a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
 - b. Size: NPS 2.
4. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

2.2 URINAL FLUSHOMETER VALVES

1. Standard: ASSE 1037.

B. Battery-Powered, Solenoid-Actuator, Piston Flushometer Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Co.
 - b. Moen Commercial.
 - c. Sloan Valve Company.
 - d. TOTO USA, INC.
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig.
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Style: Exposed.
8. Actuator: Solenoid complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

9. Trip Mechanism: Battery-powered electronic sensor complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
10. Consumption: 0.5 gal per flush.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.
- B. Examine walls and floors for suitable conditions where urinals will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.
2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.

2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

- A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed urinals and fittings.
- C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Lavatories.
- 2. Faucets.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
- 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. LEED Submittals:

- 1. Product Data for Prerequisite WE 1 and Credit WE 3: Documentation indicating flow and water consumption requirements.

- C. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

- 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of automatic faucets.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES

- A. Lavatory: Oval, vitreous china, undercounter mounted.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
 - a. American Standard America.
 - b. Kohler Co.
 - c. TOTO USA, INC.
 - 2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: For under counter mounting.
 - c. Nominal Size: Oval, 19 by 16 inches.
 - d. Color: White.

2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- A. Lavatory: Vitreous china, wall mounted, with back.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard America.
 - b. Kohler Co.
 - c. TOTO.
 - 2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: For wall hanging.
 - c. Nominal Size: Oval bowl, 19 by 16 inches.
 - d. Faucet-Hole Punching: Three holes, 2-inch centers.
 - e. Faucet-Hole Location: Top.
 - f. Color: White.

- g. Mounting Material: Chair carrier.
- 3. Support: ASME A112.6.1M, Include rectangular, steel uprights.

2.3 SOLID-BRASS, MANUALLY OPERATED FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.
- B. Lavatory Faucets\ Manual-type, two-handle mixing, commercial, solid-brass valve.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard America.
 - b. Chicago Faucets; Geberit Company.
 - c. Kohler Co.
 - d. Moen Commercial.
 - 2. Standard: ASME A112.18.1/CSA B125.1.
 - 3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 - 4. Body Type: Centerset.
 - 5. Body Material: Commercial, solid brass.
 - 6. Finish: Polished chrome plate.
 - 7. Maximum Flow Rate: 0.5 gpm.
 - 8. Mounting Type: Deck, exposed
 - 9. Valve Handle(s): Single lever.
 - 10. Spout: Rigid type.
 - 11. Spout Outlet: Laminar flow
 - 12. Drain: Not part of faucet.

2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.
- B. Description: Chrome-plated-brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.5 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.

- C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Loose key Wheel handle.
- F. Risers:
 - 1. NPS 3/8.
 - 2. Chrome-plated, soft-copper flexible tube riser.

2.6 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece, with side connection for trap primer where required.
- C. Trap:
 - 1. Size: NPS 1-1/4.
 - 2. Material: Chrome-plated, 17 gauge two-piece, two-piece, cast-brass trap, with clean-out plug, and ground-joint swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange. Trap to have cleanout plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.
- B. Examine counters and walls for suitable conditions where lavatories will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install lavatories level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

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SECTION 224216.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Service basins.
 - 2. Utility sinks.
 - 3. Sink faucets.
 - 4. Laminar-flow, faucet-spout outlets.
 - 5. Supply fittings.
 - 6. Waste fittings.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite WE 1 and Credit WE 3: Documentation indicating flow and water consumption requirements.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

A. Service Basins: Terrazzo, floor mounted.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Acorn Engineering Company.
 - b. Crane Plumbing, L.L.C.
 - c. Florestone Products Co., Inc.
 - d. Stern-Williams Co., Inc.
2. Fixture:
 - a. Standard: IAPMO PS 99.
 - b. Shape: Five sided.
 - c. Nominal Size: 24 by 24 inches.
 - d. Height: 12 with dropped front.
 - e. Tiling Flange: As required.
 - f. Rim Guard: On front top surfaces.
 - g. Color: Not applicable.
 - h. Drain: Grid with NPS 3 outlet.
3. Mounting: On floor and flush to wall.
4. Faucet: As scheduled.

2.2 UTILITY SINKS

A. Utility Sinks: Stainless steel, counter mounted.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Tabco.
 - b. Eagle Group; Foodservice Equipment Division.
 - c. Elkay Manufacturing Co.
 - d. Griffin Products, Inc.
 - e. Just Manufacturing.
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Type: Ledge back.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

- c. Number of Compartments: One.
 - d. Overall Dimensions: As scheduled.
 - e. Metal Thickness: As scheduled..
 - f. Compartment:
 - 1) Dimensions: As scheduled.
 - 2) Drain: Basket with NPS 2 tailpiece.
 - 3) Drain Location: As scheduled
- 3. Faucet(s): .
 - a. Number Required: One.
 - b. Mounting: On ledge.
- 4. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Trap(s):
 - 1) Size: 2 inch NPS .
 - 2) Material: Chrome-plated, two-piece, cast-brass trap, with clean-out plug, and ground-joint swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated brass or steel wall flange.
 - 3) Tailpiece to be provided with side connection for trap primer where required.
- 5. Mounting: On counter with sealant.

2.3 SINK FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.
- B. Sink Faucets : Manual type mixing valve.
 - 1. Commercial, Solid-Brass Faucets.
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1) American Standard America.
 - 2) Bradley Corporation.
 - 3) Chicago Faucets.
 - 4) Elkay Manufacturing Co.
 - 5) Kohler Co.
 - 6) Moen commercial Incorporated.
 - 7) Zurn Plumbing Products Group.
 - 2. Standard: ASME A112.18.1/CSA B125.1.
 - 3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
 - 4. Body Type: Centerset, Widespread or Single hole as scheduled.
 - 5. Body Material: Commercial, solid brass.
 - 6. Finish: Polished chrome plate.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

7. Maximum Flow Rate: 2.2 gpm.
8. Handle(s): Lever or Wrist blade, as scheduled
9. Mounting Type: Deck, concealed or Deck, exposed, as scheduled.
10. Spout Type: Rigid, solid brass, Swing, solid brass, Rigid gooseneck or Swivel gooseneck as scheduled.
11. Spout Outlet Laminar flow.

2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. AM Conservation Group, Inc.
 2. Chronomite Laboratories, Inc.
 3. NEOPERL, Inc.
- C. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.5 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Loose key.
- F. Risers:
 1. NPS 1/2 inch
 2. Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.6 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.
- B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
- C. Set floor-mounted sinks in leveling bed of cement grout.
- D. Install water-supply piping with stop on each supply to each sink faucet.
 - 1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 2. Install stops in locations where they can be easily reached for operation.
- E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- F. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- G. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01

- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Eyewash equipment.
 - 2. Combination units.
 - 3. Water-tempering equipment.

1.3 DEFINITIONS

- A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
- C. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
- C. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.
- D. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

PART 2 - PRODUCTS

2.1 EYEWASH EQUIPMENT

2.2 EYE/FACE WASH EQUIPMENT

- A. Sink, Swivel-Type, Plumbed Eyewash Unit,
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Acorn Safety; a division of Acorn Engineering Company.
 - b. Bradley Corporation.
 - c. Guardian Equipment Co.
 - d. Speakman Company.
 - 2. Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - 3. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
 - 4. Control-Valve Actuator: Movement of spray-head assembly to position over sink.
 - 5. Spray-Head Assembly: Two spray heads with offset piping.
 - 6. Mounting: Deck next to sink.

2.3 COMBINATION UNITS

- A. Accessible, Recessed Plumbed Emergency Shower with Eye/Face Wash Combination Units:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Acorn Safety.
 - b. Bradley Corporation.
 - c. Guardian Equipment Co.
 - d. Speakman Company.

2. Piping:
 - a. Material: Chrome-plated brass or stainless steel
 - b. Unit Supply: NPS 1 minimum.
 - c. Unit Drain: Outlet at back or side near bottom.
3. Shower:
 - a. Capacity: Not less than 20 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Heavy duty stainless steel panic bar, pull down operation.
 - d. Shower Head: 10-inch-minimum diameter, chrome-plated brass or stainless steel.
 - e. Mounting: Through the ceiling, support from structure.
4. Eye/Face Wash Unit:
 - a. Capacity: Not less than 3 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull down door.
 - d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
 - e. Receptor: Stainless steel bowl.
 - f. Mounting: Stainless steel recessed cabinet.

2.4 WATER-TEMPERING EQUIPMENT

- A. Hot- and Cold-Water, Water-Tempering Equipment:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Acorn Safety.
 - b. Guardian Equipment Co.
 - c. Leonard Valve Company.
 - d. Powers.
 2. Description: Factory-fabricated equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
 - b. Supply Connections: For hot and cold water.

2.5 SOURCE QUALITY CONTROL

- A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures. Use ball valve if specific type valve is not indicated. Install valves chained or locked in open position. Install valves in locations where they can be fully accessible for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping".
 - 1. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
- E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- G. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- H. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 CONNECTIONS

- A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

- B. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- C. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust or replace fixture flow regulators for proper flow.
- B. Adjust equipment temperature settings.

END OF SECTION 224500

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SECTION 224716 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes pressure water coolers and related components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pressure water cooler.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite WE 1: Documentation indicating flow and water consumption requirements.
- C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filter Cartridges: Two for each type and size indicated.

PART 2 - PRODUCTS

- A. Pressure Water Coolers Recessed.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkay Manufacturing Co.
 - b. Halsey Taylor.
 - c. Haws Corporation.
 - d. Tri Palm International, LLC.
2. Standards:
 - a. Comply with NSF 61 Annex G.
 - b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
 - c. Comply with ICC A117.1.
3. Cabinet: All stainless steel
4. Bubbler: One, with adjustable stream regulator, located on deck.
5. Control: Push bar.
6. Drain: Grid with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
9. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
10. Cooling System: Electric, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
11. Ventilation Grille: Stainless steel, located below water cooler.
12. Support: Mounting frame for attaching to substrate.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
- B. Examine walls and floors for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Set freestanding pressure water coolers on floor.
- C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- D. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers to mounting frames.
- E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball or gate shutoff valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

- A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

SECTION 226113 - COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air."
- B. Related Requirements:
 - 1. Section 115313 "Laboratory Fume Hoods" for compressed-air outlets in laboratory fume hoods.
 - 2. Section 123553 "Laboratory Casework" for compressed-air outlets in laboratory casework.
 - 3. Section 226119 "Compressed-Air Equipment for Laboratory Facilities" for air compressors and specialties.

1.3 DEFINITIONS

- A. Nonmedical compressed-air piping systems include laboratory air piping systems.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Certificates: For compressed-air manifolds, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Material Certificates: Signed by Installer certifying that compressed-air piping materials comply with requirements for positive-pressure gas systems.
- D. Brazing certificates.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Air Piping Systems for Laboratory Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
- B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Laboratory air operating at 125 psig .

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Compressed-air system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the manifold will remain in place without separation of any parts when subjected to the seismic forces specified and will be fully operational after the seismic event."

2.3 PIPES, TUBES, AND FITTINGS

- A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1

for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.

- B. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
- C. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- D. Flexible Pipe Connectors:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Hyspan Precision Products, Inc.
 - d. Mercer Gasket & Shim, Inc.
 - e. Metraflex Company (The).
 - f. Proco Products, Inc.
 - g. Unaflex.
 - h. Universal Metal Hose; a Hyspan Co.
 - 2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 250 psig minimum.
 - b. End Connections: Plain-end copper tube.

2.4 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.

2.5 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
- B. Ball Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. NIBCO INC.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

2. Standard: MSS SP-110.
3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever.
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions and manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

C. Check Valves:

1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. NIBCO INC.
2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig minimum.
4. Operation: Spring loaded.
5. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

D. Safety Valves:

1. Bronze body.
2. ASME-construction, poppet, pressure-relief type.
3. Settings to match system requirements.

E. Pressure Regulators:

1. Bronze body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
3. Manual pressure-setting adjustment.
4. Rated for 250-psig minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

2.6 COMPRESSED-AIR SERVICE CONNECTIONS

A. General Requirements for Laboratory Compressed-Air Service Connections:

1. Suitable for specific air pressure and service listed.

2.7 NITROGEN

- A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Cleaning of Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
 - 1. Clean gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
 - 2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
 - a. Scrub to ensure complete cleaning.
 - b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Comply with NFPA 99 for installation of compressed-air piping.
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- F. Install piping adjacent to equipment and specialties to allow service and maintenance.
- G. Install compressed-air piping with 1 percent slope downward in direction of flow.
- H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

- I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
- K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."
- L. Install piping to permit valve servicing.
- M. Install piping free of sags and bends.
- N. Install fittings for changes in direction and for branch connections.
- O. Install air piping to air service connections specified in this Section, to air service connections in equipment specified in Section 226313 "Gas Piping for Laboratory Facilities," and to equipment specified in other Sections requiring air service.
- P. Piping Restraint Installation: Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- Q. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- R. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.
- S. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

- A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.
- B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
- C. Install pressure regulators on compressed-air piping where reduced pressure is required.
- D. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.4 JOINT CONSTRUCTION

- A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
- B. Threaded Joints: Apply appropriate tape to external pipe threads.
- C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Vertical Piping: MSS Type 8 or Type 42, clamps.
- D. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
- E. Multiple, Straight, Horizontal Piping Runs;. Support pipe on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52, spring hangers.
- G. Support horizontal piping within 12 inches of each fitting and coupling.
- H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
 - 2. NPS 3/4: 84 inches with 3/8-inch rod.
 - 3. NPS 1: 96 inches with 3/8-inch rod.
 - 4. NPS 1-1/4: 108 inches with 3/8-inch rod.
 - 5. NPS 1-1/2: 10 feet with 3/8-inch rod.
 - 6. NPS 2: 11 feet with 3/8-inch rod.
 - 7. NPS 2-1/2: 13 feet with 1/2-inch rod.
 - 8. NPS 3: 14 feet with 1/2-inch rod.
- J. Install supports for vertical copper tubing every 10 feet.

3.6 IDENTIFICATION

- A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."
1. Laboratory Air: Black letters on yellow-and-white checkerboard background.

3.7 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN LABORATORY FACILITIES

- A. Tests and Inspections:
1. Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of compressed-air piping systems concurrently with tests, inspections, and certification of laboratory gas piping and laboratory vacuum piping systems.
 2. Preparation: Perform the following Installer tests according to requirements in ASSE Standard #6010:
 - a. Initial blowdown.
 - b. Initial pressure test.
 - c. Cross-connection test.
 - d. Piping purge test.
 - e. Standing pressure test for positive-pressure compressed-air piping.
 - f. Repair leaks and retest until no leaks exist.
 3. System Verification: Perform the following tests and inspections according to ASSE Standard #6020, and ASSE Standard #6030:
 - a. Standing pressure test.
 - b. Individual-pressurization or pressure-differential cross-connection test.
 - c. Valve test.
 - d. Piping purge test.
 - e. Piping particulate test.
 - f. Piping purity test.
 - g. Final tie-in test.
 - h. Operational pressure test.
 - i. Laboratory air purity test.
 - j. Verify correct labeling of equipment and components.
 4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures, materials, and gases used.
 - c. Test methods used.
 - d. Results of tests.
- B. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.8 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN LABORATORY FACILITIES

A. Tests and Inspections:

1. Piping Leak Tests for Compressed-Air Piping: Cap and fill compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
2. Repair leaks and retest until no leaks exist.
3. Inspect filters and pressure regulators for proper operation.

B. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.9 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.
- C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 PIPING SCHEDULE

Laboratory air piping less than NPS 3 and Operating at less than 185 psig: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.11 VALVE SCHEDULE

- A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

END OF SECTION 226113

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SECTION 226119 - COMPRESSED-AIR EQUIPMENT FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Scroll air compressors.
 - 2. Inlet-air filters.
 - 3. Desiccant compressed-air dryers.
 - 4. Compressed-air filter assemblies.

1.3 DEFINITIONS

- A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.
- B. Laboratory Air Equipment: Compressed-air equipment and accessories for nonmedical laboratory facilities.
- C. Air equipment includes laboratory air compressors and accessories.
- D. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For air compressors and compressed-air dryers systems.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Certificates: For air compressors, accessories, and components from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressed-air equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Air-Compressor, Inlet-Air Filter Elements: Two units.
 - 2. Belts: Two for each belt-driven compressor.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Laboratory Air Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.
- B. Seismic Performance: Air compressors and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the air compressor and receiver will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS FOR AIR COMPRESSORS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
- C. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 4. Motor Overload Protection: Overload relay in each phase.
 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 6. Automatic control switches to alternate lead-lag air compressors for duplex and sequence lead-lag air compressors for multiplex air compressors.
 7. Instrumentation: Include discharge-air and receiver pressure gages, air-filter maintenance indicator, hour meter, air-compressor discharge-air and coolant temperature gages, and control transformer.
 8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
- D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
 2. Interior Finish: Corrosion-resistant coating.
 3. Accessories: Include safety valve, pressure gage, automatic drain, and pressure regulator.
- E. Mounting Frame: Fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 SCROLL AIR COMPRESSORS

- A. Scroll Air Compressors:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- a. Allied Healthcare Products, Inc.; Chemetron Division.
 - b. BeaconMedaes.
 - c. Ohio Medical Corporation; Squire-Cogswell brand.
 - d. Powerex, Inc.
2. Description: Packaged unit.
3. Air Compressor(s): Single-stage, oil-free, rotary, oscillating-volute type of construction that prohibits oil from entering compression chamber.
 - a. Mounting: Freestanding.

B. Capacities and Characteristics:

1. Compressed-Air Service: Refer to drawings for equipment schedule

2.4 INLET-AIR FILTERS

- A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.5 COMPRESSED-AIR DRYERS

A. Desiccant Compressed-Air Dryers:

1. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 deg F, 100-psig air at dew point. Include dew point controlled purge, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory air applications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.2 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation:

1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install the following devices on compressed-air equipment:
 - a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
 - b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
 - c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Laboratory Compressed-Air Equipment Installation:

1. Install compressed-air equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
 - a. Anchor air compressors to surface according to manufacturer's written instructions and seismic criteria applicable to Project.

3.3 CONNECTIONS

- A. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for compressed-air piping specified in Section 226113 "Compressed-Air Piping for Laboratory Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance.
- D. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

3.4 IDENTIFICATION

- A. Identify laboratory compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL LABORATORY-FACILITY COMPRESSED-AIR EQUIPMENT

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compressed-Air Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of compressed-air equipment concurrently with tests, inspections, and certification of compressed-air piping systems.
 - 2. Preparation: Perform compressed-air equipment tests according to requirements in NFPA 99 for the following:
 - a. Air-quality purity test.
 - b. System operation test.
 - 3. Equipment Verification: Comply with requirements in ASSE 6020 and ASSE 6030 for verification of compressed-air equipment.
 - 4. Replace damaged and malfunctioning controls and equipment.
 - 5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures, materials, and gases used.
 - c. Test methods used.
 - d. Results of tests.
- C. Components will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air-compressor inlet filters and piping are clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure, but not higher than rating of system components.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver tank(s).
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.
- B. Prepare written report documenting testing procedures and results.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- C. Provide all printed materials in the OEM and on CD/DVD.
- D. Provide video recording of session.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors, compressed-air dryers, and compressed-air filter assemblies.
- B. Provide all printed materials in the OEM and on CD/DVD.
- C. Provide video recording of session.

END OF SECTION 226119

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SECTION 226213 - VACUUM PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Waste anesthetic gas disposal piping, designated "WAGD."
 - 2. Laboratory low-vacuum piping, designated "laboratory low vacuum."
- B. Related Requirements:
 - 1. Section 115313 "Laboratory Fume Hoods" for vacuum inlets in laboratory fume hoods.
 - 2. Section 123553 "Laboratory Casework" for vacuum inlets in laboratory casework.
 - 3. Section 226219 "Vacuum Equipment for Laboratory Facilities" for vacuum producers and accessories.

1.3 DEFINITIONS

- A. WAGD: Waste anesthetic gas disposal.
- B. Vacuum piping systems include laboratory vacuum and, WAGD, piping systems.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Material Certificates: Signed by Installer certifying that medical vacuum piping materials comply with requirements in NFPA 99.
- C. Brazing certificates.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Medical Vacuum Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
- B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Laboratory low vacuum operating at 20 in. Hg

2.2 PIPES, TUBES, AND FITTINGS

- A. Comply with NFPA 99 for medical vacuum piping materials.
- B. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.
- C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service.
- D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
- F. Flexible Pipe Connectors:
 - 1. Manufacturers: Subject to compliance with requirements provide products by one of the following:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Hyspan Precision Products, Inc.
 - d. Mercer Gasket & Shim, Inc.
 - e. Metraflex Company (The).
 - f. Proco Products, Inc.
 - g. Unaflex.
 - h. Universal Metal Hose; a Hyspan Co.
2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig minimum.
 - b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.
- C. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
 1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.
- D. Copper-Alloy Ball Valves:
 1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. NIBCO INC.
 2. Standard: MSS SP-110.
 3. Description: Three-piece body, brass or bronze.
 4. Pressure Rating: 300 psig minimum.
 5. Ball: Full-port, chrome-plated brass.
 6. Seats: PTFE or TFE.
 7. Handle: Lever.
 8. Stem: Blowout proof with PTFE or TFE seal.
 9. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions and] manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.
- E. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. NIBCO INC
2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig minimum.
4. Operation: Spring loaded.
5. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

2.4 VACUUM SERVICE CONNECTIONS

A. General Requirements for Medical Vacuum Service Connections:

1. Suitable for specific vacuum service listed.

2.5 NITROGEN

A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

- #### A. Cleaning of Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
 2. Wash gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
 - a. Scrub to ensure complete cleaning.
 - b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

- #### A. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, vacuum producer sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

**Interdisciplinary Science Building
Webster University
Canon Design Project No. 004561.01**

- B. Comply with NFPA 99 for installation of vacuum piping.
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- F. Install piping adjacent to equipment and specialties to allow service and maintenance.
- G. Install vacuum piping with 1 percent slope downward in direction of flow.
- H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.
- I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- J. Provide drain leg and drain trap at end of each main and branch and at low points.
- K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."
- L. Install piping to permit valve servicing.
- M. Install piping free of sags and bends.
- N. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.
- O. Install vacuum piping from vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory Facilities," and to equipment specified in other Sections requiring vacuum service.
- P. Piping Restraint Installation: Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- Q. Install vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- R. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.
- S. Install unions in copper vacuum tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

- A. Install shutoff valve at each connection to and from vacuum equipment and specialties.
- B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.
- C. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Apply appropriate tape to external pipe threads.
- D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Vertical Piping: MSS Type 8 or Type 42, clamps.
- D. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
- E. Multiple, Straight, Horizontal Piping Runs; Support pipe on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52, spring hangers.
- G. Support horizontal piping within 12 inches of each fitting and coupling.

- H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
 - 2. NPS 3/4: 84 inches with 3/8-inch rod.
 - 3. NPS 1: 96 inches with 3/8-inch rod.
 - 4. NPS 1-1/4: 108 inches with 3/8-inch rod.
 - 5. NPS 1-1/2: 10 feet with 3/8-inch rod.
 - 6. NPS 2: 11 feet with 3/8-inch rod.
 - 7. NPS 2-1/2: 13 feet with 1/2-inch rod.
 - 8. NPS 3: 14 feet with 1/2-inch rod.
- J. Install supports for vertical copper tubing every 10 feet.

3.6 IDENTIFICATION

- A. Install identifying labels and devices for vacuum piping systems. Use the following or similar captions and color-coding for piping products:
 - 1. WAGD: White letters on violet background.
 - 2. Laboratory Vacuum: Black boxed letters on white-and-black checkerboard background.

3.7 FIELD QUALITY CONTROL FOR LABORATORY FACILITY VACUUM PIPING

- A. Tests and Inspections:
 - 1. Piping Leak Tests for Vacuum Piping: Test new piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - a. Test Pressure for Copper Tubing: 150 psig.
 - 2. Repair leaks and retest until no leaks exist.
 - 3. Inspect filters for proper operation.
- B. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.8 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.
- C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.9 PIPING SCHEDULE

- A. Flanges may be used where connection to flanged equipment is required.
- B. WAGD Piping: Use copper medical gas tube, wrought-copper fittings, and brazed joints.
- C. Laboratory Low-Vacuum Piping: Use the following piping materials for each size range:
 - 1. NPS 4 and Smaller: Copper medical gas water tube, wrought-copper fittings, and brazed joints.

3.10 VALVE SCHEDULE

- A. Shutoff Valves:
 - 1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.
 - a. NPS 4 and Smaller: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

END OF SECTION 226213

SECTION 226219 - VACUUM EQUIPMENT FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Rotary, dry-claw vacuum pumps.

1.3 DEFINITIONS

- A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in acfm.
- B. Laboratory Vacuum Equipment: Vacuum producers and accessories for nonmedical laboratory facilities.
- C. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.
- D. WAGD: Waste anesthetic gas disposal for medical-surgical applications in healthcare facilities.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For vacuum producers.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Seismic Qualification Certificates: For vacuum producers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: Two for each belt-driven vacuum producer.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Laboratory Vacuum Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vacuum equipment mounting.
- B. Seismic Performance: Vacuum producers and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the vacuum producer and receiver or separator will remain in place without separation of any parts when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.
- C. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - 2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 - 4. Motor Overload Protection: Overload relay in each phase.
 - 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - 6. Automatic control switches to alternate lead-lag vacuum pumps for duplex and sequence lead-lag vacuum pumps for multiplex vacuum pumps.
 - 7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
 - 8. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.
- D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
 - 1. Interior Finish: Corrosion-resistant coating.
 - 2. Accessories: Include vacuum relief valve, vacuum gage, and drain.
- E. Mounting Frames: Fabricate base and attachment to vacuum pump and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 ROTARY, DRY-CLAW VACUUM PUMPS

- A. Rotary, Dry-Claw Vacuum Pumps:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.
 - b. BeaconMedaes.
 - c. Ohio Medical Corporation.
 - d. Powerex, Inc.
 - 2. Description: Packaged unit.
 - 3. Vacuum Pump(s): Single-stage, rotary, dry-claw type.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Coupling: Non-lubricated, flexible type.
 - b. Cooling System: Air cooled.
 - c. Capacity Control: Capacity modulation between zero and 100 percent vacuum delivery. Include necessary control to hold constant vacuum. When vacuum demand is zero, unload unit by using vacuum switch and blowdown valve.
- 4. Receiver: ASME construction steel tank with vacuum relief valve.
- 5. Outlet silencers on discharge connections.
- B. Capacities and Characteristics:
 - 1. Vacuum Service: Refer to drawings for equipment schedule.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

- A. Install vacuum equipment for laboratory facilities according to ASSE 6010.
- B. Equipment Mounting:
 - 1. Install vacuum producers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." or Section 033053 "Miscellaneous Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
- C. Install vacuum equipment anchored to substrate.
- D. Orient equipment so controls and devices are accessible for servicing.
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Install the following devices on vacuum equipment:
 - 1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.

2. Drain Valves: Install on receivers and separators. Discharge receiver condensate over nearest floor drain. Discharge separator or air evacuation fluids by direct connection into sanitary waste piping system.
3. Install according to ASSE 6010 and NFPA 99.

3.3 CONNECTIONS

- A. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping for Laboratory Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance.
- D. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.

3.4 IDENTIFICATION

- A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL VACUUM EQUIPMENT

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative]:
 1. Vacuum Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum equipment concurrently with tests, inspections, and certification of medical vacuum piping systems.
 2. Preparation: Perform medical vacuum equipment tests according to requirements in NFPA 99 for the following:
 - a. System operation test.
 3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030 for verification of vacuum equipment.
 4. Replace damaged and malfunctioning controls and equipment.
 5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures and materials used.
 - c. Test methods used.
 - d. Results of tests.

- C. Components will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that vacuum producer outlet piping is clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver and separator tank.
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.
- B. Verify that vacuum equipment is installed and connected according to the Contract Documents.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.
- D. Prepare written report documenting testing procedures and results.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain vacuum producers.
- B. Provide all printed materials in OEM and on CD/DVD.
- C. Provide video recording of session.

END OF SECTION 226219

SECTION 226313 - GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Carbon dioxide piping, designated "medical carbon dioxide."
 - 2. Nitrogen piping, designated "medical nitrogen."
 - 3. Nitrous oxide piping, designated "medical nitrous oxide."
 - 4. Oxygen piping, designated "medical oxygen."
- B. Owner-Furnished Material:
 - 1. Medical gas manifolds and regulators. (OFCI).
 - 2. Owner will furnish gases for medical gas concentration testing specified in this Section.
- C. Related Requirements:
 - 1. Section 115313 "Laboratory Fume Hoods" for gas outlets in laboratory fume hoods.
 - 2. Section 123553 "Laboratory Casework" for gas outlets in casework.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. Medical gas piping systems include medical carbon dioxide, medical nitrogen, medical nitrous oxide, medical oxygen, compressed air and vacuum for healthcare facility patient care.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

- B. Material Certificates: Signed by Installer certifying that medical gas piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.
- C. Brazing certificates.
- D. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For medical gas piping specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Medical Gas Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
- B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Medical carbon dioxide operating at 50 to 55 psig.
- B. Medical nitrogen operating at 160 to 185 psig.
- C. Medical nitrous oxide operating at 50 to 55 psig.
- D. Medical oxygen operating at 50 to 55 .

2.2 PIPES, TUBES, AND FITTINGS

- A. Comply with NFPA 99 for medical gas piping materials.
- B. Copper Medical Gas Tube: ASTM B 819, Type K and Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service; or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

- C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
- D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

2.3 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.

2.4 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
- B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.
 - 1. Zone-Valve Boxes:
 - a. Steel Box with Cover:
 - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a) Allied Healthcare Products Inc.
 - b) BeaconMedaes
 - c) Amico Corporation.
 - d) Ohio Medical Corporation.
 - e) Tri-Tech Medical
 - b. Steel Box with Stainless-Steel Cover:
 - c. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.
 - 1) Interior Finish: Factory-applied white enamel.
 - 2) Cover Plate: Aluminum or stainless steel with frangible or removable windows.
 - 3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

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C. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. Marwin Valve; a division of Richards Industries.
 - f. NIBCO INC.
 - g. Ohio Medical Corporation.
 - h. Tri-Tech Medical Inc.
2. Standard: MSS SP-110.
3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever.
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions and manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

D. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.; Chemetron Division.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. Ohio Medical Corporation.
 - f. Tri-Tech Medical Inc.
2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig minimum.
4. Operation: Spring loaded.
5. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

E. Safety Valves:

1. Bronze body.
2. ASME-construction, poppet, pressure-relief type.
3. Settings to match system requirements.

F. Pressure Regulators:

1. Bronze or Stainless-steel body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.

3. Manual pressure-setting adjustment.
4. Rated for 250-psig minimum inlet pressure.
5. Capable of controlling delivered gas pressure within 0.5 psig for each 10-psig inlet pressure.

2.5 MEDICAL GAS SERVICE CONNECTIONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allied Healthcare Products Inc.; Chemetron Division.
 2. Amico Corporation.
 3. BeaconMedaes.
 4. Ohio Medical Corporation.
 5. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
 6. Tri-Tech Medical Inc.
- B. General Requirements for Medical Gas Service Connections:
1. Suitable for specific medical gas pressure and suction service listed.
 2. Include roughing-in assemblies, finishing assemblies, and cover plates.
 3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
 4. Recessed-type units made for concealed piping unless otherwise indicated.
- C. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.
 2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed. Suction inlets to be without secondary valve.
 3. Double seals that will prevent gas leakage.
 4. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.
- D. Finishing Assembly:
1. Brass housing with primary check valve.
 2. Double seals that will prevent gas leakage.
 3. Cover plate with gas-service label.
- E. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
1. Medical Carbon Dioxide: D.I.S.S. No. 1080.
 2. Medical Nitrogen: D.I.S.S. No. 1120.
 3. Medical Nitrous Oxide: D.I.S.S. No. 1040.
 4. Medical Oxygen: D.I.S.S. No. 1240.

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- F. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
 - 1. Medical Air: D.I.S.S. No. 1160.
- G. D.I.S.S. Suction Service Connections: Inlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
 - 1. Medical Vacuum: D.I.S.S. No. 1220.
 - 2. WAGD: D.I.S.S. No. 2220.
- H. Cover Plates: One piece, aluminum or stainless steel and permanent, color-coded, identifying label matching corresponding service.

2.6 MEDICAL GAS MANIFOLDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Cryogenics.
 - 2. Allied Healthcare Products Inc.; Chemetron Division.
 - 3. Amico Corporation.
 - 4. BeaconMedaes.
 - 5. Ohio Medical Corporation.
 - 6. Tri-Tech Medical Inc.
- B. Comply with NFPA 99 for high-pressure medical gas cylinders.
- C. Manifold and Headers:
 - 1. Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks.
 - 2. Designed for 2000-psig minimum inlet pressure except nitrous oxide manifolds may be designed for 800 psig and carbon dioxide manifolds may be designed for 1500 psig .
 - 3. Cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1.
 - 4. Individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
- D. Mounting: Wall with mounting brackets for manifold control cabinet and headers.
- E. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.
- F. Medical Oxygen Manifolds: For two cylinders and 55-psig line pressure.
- G. Medical Gas Cylinders: Furnished by Owner.

2.7 GAS CYLINDER STORAGE RACKS

- A. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.

2.8 NITROGEN

- A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
 - 1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
 - 2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal of water.
 - a. Scrub to ensure complete cleaning.
 - b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Comply with NFPA 99 for installation of medical gas piping.
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- F. Install piping adjacent to equipment and specialties to allow service and maintenance.

- G. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.
- H. Install piping to permit valve servicing.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and for branch connections.
- K. Install medical gas piping to medical gas service connections specified in this Section, to medical gas service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.
- L. Piping Restraint Installation: Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- M. Install medical gas service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- N. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.
- O. Install unions in copper tubing adjacent to each valve and at final connection to each specialty and piece of equipment.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

- A. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.
- B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.
- C. Install zone valves and gages in valve boxes. Arrange valves so largest valve is lowest. Rotate valves to angle that prevents closure of cover when valve is in closed position.
- D. Install pressure regulators on gas piping where reduced pressure is required.

3.4 JOINT CONSTRUCTION

- A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

- B. Threaded Joints: Apply appropriate tape to external pipe threads.
- C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.

3.5 GAS SERVICE COMPONENT INSTALLATION

- A. Assemble patient-service console with service connections. Install with supplies concealed in walls. Attach console box or mounting bracket to substrate.
- B. Install nitrogen pressure-control panels in walls. Attach to substrate.
- C. Install gas cylinders and connect to piping.
- D. Install gas manifolds with seismic restraints.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
- D. Multiple, Straight, Horizontal Piping Runs;. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- E. Support horizontal piping within 12 inches of each fitting and coupling.
- F. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/8 and NPS 1/2 : 72 inches with 3/8-inch rod.
 - 2. NPS 3/4: 84 inches with 3/8-inch rod.
 - 3. NPS 1: 96 inches with 3/8-inch rod.
 - 4. NPS 1-1/4: 108 inches with 3/8-inch rod.
 - 5. NPS 1-1/2: 10 feet with 3/8-inch rod.
 - 6. NPS 2 :11 feet with 3/8-inch rod.
- H. Install supports for vertical copper tubing every 10 feet.

3.7 IDENTIFICATION

- A. Install identifying labels and devices for healthcare medical gas piping systems. Use the following or similar captions and color-coding for piping products where required.
 - 1. Carbon Dioxide: Black or white letters on gray background.
 - 2. Nitrogen: White letters on black background.
 - 3. Nitrous Oxide: White letters on blue background.
 - 4. Oxygen: White letters on green background or green letters on white background.

3.8 FIELD QUALITY CONTROL FOR MEDICAL GAS

- A. Tests and Inspections:
 - 1. Medical Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical vacuum piping systems.
 - 2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
 - a. Initial blowdown.
 - b. Initial pressure test.
 - c. Cross-connection test.
 - d. Piping purge test.
 - e. Standing pressure test for positive-pressure medical gas piping.
 - f. Standing pressure test for vacuum systems.
 - g. Repair leaks and retest until no leaks exist.
 - 3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
 - a. Standing pressure test.
 - b. Individual-pressurization or pressure-differential cross-connection test.
 - c. Valve test.
 - d. Piping purge test.
 - e. Piping particulate test.
 - f. Piping purity test.
 - g. Final tie-in test.
 - h. Operational pressure test.
 - i. Medical gas concentration test.
 - j. Verify correct labeling of equipment and components.
 - k. Verify medical gas supply sources.
 - 4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures, materials, and gases used.
 - c. Test methods used.
 - d. Results of tests.

- B. Remove and replace components that do not pass tests and inspections and retest as specified above.
- C. Prepare test and inspection reports.

3.9 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.
- C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain bulk gas storage tanks.
- B. Provide all printed materials in OEM and on CD/DVD.
- C. Provide video recording of session.

3.11 PIPING SCHEDULE

- A. Medical Gas Piping except Medical Nitrogen Piping Larger Than NPS 3 and Operating at More Than 185 psig: Type L, copper tube; wrought-copper fittings; and brazed joints.

3.12 VALVE SCHEDULE

- A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.
- B. Zone Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226313

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SECTION 226700 - PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Processed water system
- B. Deionized-water piping.

1.3 PERFORMANCE REQUIREMENTS

- A. This section of the specification covers detailed requirements for the installation of a High Purity Deionized Water System, which will supply and maintain water meeting the following requirements:
 - Resistivity < 1 megohm/cm
 - TOC < 500ppb
 - Bacteria < 100 cfu/mL
- B. Minimum Working Pressure Ratings:
 - 1. Deionized-Water Piping: 100 psig.
- D. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- E. Water to be sampled after the post filter in the distribution loop.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. LEED Submittals:
 - 1. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For water piping, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.3, "Process Piping," for piping conveying fluid at a pressure of 15 psig or greater.

PART 2 - PRODUCTS

2.1 Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following

- A. Evoqua Water Technologies LLC
- B. Marlo Incorporated
- C. Culligan International

2.2 Deionized Water System

- A. The system shall consist of a twin water softener, back-washable carbon filter, reverse osmosis skid, exchangeable mixed bed ion exchange tanks, polyethylene cone bottom tank, and high purity distribution skid.

- 1. **Water Softener:** Water softener tanks shall be piped in a twin configuration and set for metered regeneration via an in-line brass flow meter. Vessels shall be of FRP construction and rated for a maximum operating pressure of 100 psi. Units shall be sized for a flow of 3 gpm or less, per cf of resin to ensure adequate hardness removal before the RO unit. System to include a Fleck 9000, top mount multi-port brass valve and SXT controller. System to include a polyethylene brine maker. Softener to include 2 cu ft of C-211 cation resin in the sodium form with a capacity of 30,000 grains per cf. Note: Installing contractor shall provide removable pipe sections at control head to allow for free spinning of head for servicing tank while in its static upright position.

Basis for Design: Evoqua Water Technologies PTCTD12X52

- 2. **Carbon Filter:** Carbon filter tank shall be set for a timed backwash cycle utilizing a Fleck 2750 multiport brass valve and NXT controller. The controller shall include an electromechanical timer and provide a pretreatment lockout switch assembly to deactivate downstream equipment during backwash. Unit shall provide adequate removal

of chlorine before the RO. Recommended flow rate for RO feed is 3 gpm, or less, per cu ft of media. For feedwaters with high amounts of chloramines, the flow rate should be de-rated to 1-2 gpm per cu ft of carbon media. Note: Installing contractor shall provide removable pipe sections at control head to allow for free spinning of head for servicing tank while in its static upright position.

Basis For Design: Evoqua Water Technologies PTCCDS12X52

3. **Reverse Osmosis Skid:** RO skid shall be pre-engineered, pre-wired, and factor tested before delivery to the job site. System to include primary connections for inlet, outlet, and drain. Unit shall be a vertical style with a product flow rate up to 2.8 gpm. A 5 micron pre-filter is required as pre-treatment on the RO skid. The RO skid shall contain two (2) Hydranautics ESPA4-4040 4" X 40" thin film composite membranes (TFC), which shall receive softened dechlorinated water between 25 and 50 psi at an optimum temperature of 77° F. The membrane housings shall be constructed of FRP and mounted vertically, with a maximum operating pressure of 300 psi. The membranes shall have a 99 percent nominal contaminant rejection rate. The unit shall have automatic low pressure shutoff to protect the on board centrifugal feed pump. RO pump to be Grundfos CRI 3-15 rated at 3 HP. The RO shall have pressure indication for pre-filter and pump discharge, as well as primary and final pressure gauges. Unit shall have auto flush system, and remote on/off capability. Unit shall be mounted on a non-corrosive skid, complete with solid-state programmable controller housed in a NEMA 4X enclosure with audible and visible alarm system. Controller shall have liquid crystal display, multi-function key pad, visual and audible alarms, high/low pressure automatic reset, alarm silence, non-metallic NEMA 4X enclosure and be panel mounted. Controller shall have a conductivity sensor for both feed and product, temperature readout, alarm history, and have the capability for remote monitoring through Ethernet. Skid shall also contain flow meters for product, concentrate, and concentrate recycle. RO skid shall have a recovery rate of 75%. Electrical connection to be 460V 3 PH.

4.

Basis For Design: Evoqua Water Technologies Model # M41RGPV002D

Performance and Design Data

Flow Rates (gpm)				
Model Number	Product (gpm)	Feed (gpm)	Reject (gpm)	Reject Recycle (gpm)
M41RGPV002D	2.8	3.7	.9	4.5

Array Configuration					
Model Number	Vessel Array Staging	Membranes / Vessel	Membrane Quantity	Vessel Quantity	Pump Model
M41RGPV002D	1:1	1	2	2	CRI 3-15

Design Parameters

Configuration	Multi-Stage. Single Pass
Feed Temperature	77°F (25°C)
Inlet Pressure Requirements	25-50 psig
Feed water source	Well or Softened
Pre-filtration	5μ nominal
Feed water fouling index	Silt Density Index (SDI) <3

System Recovery (nominal)	75%
Membrane Salt Rejection	99% nominal (based on 2000ppm NaCl @ 225 PSI, 77 degrees F, pH 8, and 15% recovery)
Product Pressure available	25 psig
Performance basis	A specific computer projection must be run for each individual application

Operating Limits

Feed Temperature	
Minimum	50°F
Maximum	113°F
Feed Pressure	
Minimum	25 psig
Maximum	50 psig
Design Membrane Feed Pressure (@77°F)	125 psig nominal
Process	
Maximum SDI rating	3 SDI
Maximum Turbidity	1 NTU
Maximum Free Chlorine and/or Chloramines	<0.02 ppm
Maximum pH (continuous)	11 pH
Minimum pH (continuous)	4 pH
Maximum pH (cleaning – 30 minutes)	12 pH
Minimum pH (cleaning – 30 minutes)	1 pH

5. **Exchangeable Mixed Bed Deionizers:** System to include two (2) exchangeable mixed bed deionizers, which shall receive RO product water and a side stream from the distribution loop. Mixed beds to be installed in a worker/polisher configuration and accommodate a flow rate of 10 gpm. Each tank to be 14" diameter X 50" tall and contain approximately 3.6 cf of Type I mixed bed resin. Minimum output quality of the mixed beds shall be 15 megohm/cm when regenerated. Tanks to be of FRP construction with a max operating pressure of 80 psi. Tanks to include polypropylene lined interconnecting hoses for connection to the Deionized Water System Piping. Resin to be regenerated in an ISO 9001:2008 facility and with the service provider being within 150 miles of the customer's site. A 20" post filter shall be installed on the outlet of the mixed bed tanks to protect against resin breakthrough. The post filter shall include a 20" polypropylene housing and 5 micron filter. Filter shall be a melt blown, non-shedding, depth filter approved for food contact applications.
Basis for Design (Mixed Beds) – Evoqua WT Part # W5TDIMB10360FSP
Basis for Design (Filter Housing) – Evoqua WT Part # ZHCFA2001
Basis for Design (Filter Cartridge) Evoqua WT Part # FCNTF2005
6. **RO Water Storage Tank** The storage tank shall have a holding capacity of 400 gallons. The tank shall be cone bottom to insure complete tank drainage for cleaning and sanitization operations. The tank is supported by a structural steel stand painted with an acid resistant epoxy. The tank is constructed of virgin high density FDA approved polyethylene and shall be 48" Diameter X 72" Tall. Storage tank to include factory installed fittings. Fittings below the water level shall be polyethylene coupling fittings welded and tapered into the tank wall. A spray nozzle shall be mounted in the tank the

tank to provide complete wetting of the tank and full sanitization. Tank to include a gasketed seal for air tight access to the tank interior. Tank level to be controlled by a pressure sensor connected to the pump skid control panel. Storage tank shall include a 20" .2 micron vent filter assembly to prevent particulates and airborne bacteria from entering the tank. The tank shall have a 1" or larger connection at the top of the tank for overflow conditions. The overflow shall be piped in the field by the installing contractor and include a "P" trap, which can be filled with water or food grade oil to prevent air from entering the tank.

Basis For Design (Tank): Terracon CXC0400 cone bottom storage tanks.

Basis For Design: (Vent Filter): Evoqua WT ZHCFA2001 polypropylene filter housings, FCEAF20S2 series hydrophobic vent filter cartridges.

7. **Distribution Pump Skid:** The distribution skid shall be constructed of carbon steel, powder or epoxy coated, and configured to provide for ease of maintenance. Maximum skid dimensions to be 47" W X 72"L. Butt fusion PVDF shall be utilized as the piping material for the skid. Skid interconnecting piping and wiring is completed at the factory. Pressure indicators shall be installed to monitor pump discharge pressure and pressure drops across skid components. Skid to be completely prefabricated, pre-wired, and hydrostatically tested providing for easy, straightforward, integration of the equipment into the remainder of Deionized Water System. Field connections include 2" flanged suction manifold, 1 1/4" flanged discharge manifold, 3/4" side stream flange, a power connection to the skid mounted control panel, and wiring from the skid mounted control panel to tank level switch. Distribution skid shall be controlled by a Allen Bradley MicroLogix series PLC and PanelView touch screen HMI or equivalent. PLC to allow connection to BMS for remote monitoring of the system performance. Skid voltage to be 460V 3 PH. Skid shall include the following components.
 - a. **Distribution Pumps (duplex):** The pumps shall be Grundfos CRNE 10-6. Pump designed for an initial flow of 29 gpm @ 204 ft/hd (88.5 psi) with the ability to support a future flow of 37 gpm. Pumps shall be 316 stainless steel with top mounted variable frequency drive motor (VFD) and 150# ANSI flange connections. The pumps shall be controlled by a pressure transducer (supplied with pump) and be installed in the common discharge piping to maintain system pressure required by the project requirements. The pump shall be terminated at a fused blade disconnect or pump control panel.

Basis For Design: Grundfos CRNE 10-6 series centrifugal VFD pumps.

- b. **Ultraviolet Sterilizer:** UV unit enclosure to be manufactured of 304 stainless steel and all wetted parts to be made of 316L electro polished stainless steel. UV shall contain four lamps enclosed in a quartz sleeve and emit a dosage greater than 30,000 microwatt sec./cm² of 254 nanometer ultraviolet light. Unit to include stainless steel baffles to induce turbulence and prevent channeling, maximizing the exposure to ultraviolet radiation. Connections to be 150# flange connection. Stainless steel light traps are to be used to protect the PVDF piping. Unit shall be rated for a minimum flow rate of 34 gpm of deionized water.
- Basis For Design: Aquafine CSL 4R Plus UV Sterilizer***

 - c. **Final Filter:** The multi-cartridge filter housings shall be made of 316L stainless steel with band clamp or swing bolt closure to allow cartridges to be changed quickly and easily. Housing shall have 2 " flanged connections and sized for Six (6) 20" ele-

ments. Housing to contain seven (6) 20" .2 micron Code O filters and shall accommodate a flow rate of 34 gpm with a clean pressure drop to be no more than 2 psi. Cartridges to be .2 micron absolute rated polysulfone membrane filters with double o-ring seal. Cartridges shall meet criteria for USP Class VI Biological test for plastics and manufactured from materials which are FDA listed for food contact applications in Title 21 of the U.S. code of Federal regulations.

- d. **Resistivity Monitor:** Function is to monitor the quality after the mixed bed deionization tanks and measure final product quality produced to the building distribution loop. The system shall utilize a two channel Thornton M300 process meter connected to PLC. Monitoring system shall include one sensor to be connected on the outlet of the skid and one to be shipped loose and field installed after the exchangeable mixed beds. Patch cords shall be included with sensors.
- e. **Flow Measurement:** The system shall include a GF Signet paddlewheel flow sensor installed in the final product stream and connected to the skid PLC via patch cord. The polishing slip stream shall utilize an acrylic inline rotometer to measure flow.
- f. **Tank Level Control:** Tank level to be controlled by a pressure sensor connected to the PLC. Tank process meter shall be programmed for tank fill, RO shut off, low level pump shut off and high water alarm.

2.3 PLASTIC PIPE AND FITTINGS

A. PVDF Pipe and Fittings: Made from ASTM D 3222, PVDF resin.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Asahi/America.
 - b. Georg Fischer Inc.
 - c. NIBCO INC.
 - d. Orion Fittings; a Watts Water Technologies company.
- 2. Polyvinylidene Fluoride pipe shall be manufactured from virgin Kynar® resin. Pipe shall be manufactured to an SDR (Standard Dimension Ratio) series. Pipe sizes 1/2" (20mm) through 2 1/2" (75mm) shall be manufactured to have a pressure rating of 232 psi (PN16) when measured at 68°F (20°C). Pipe internal surface finish shall be $Ra \leq 20.0\mu\text{in}$ ($5\mu\text{m}$).
- 3. Polyvinylidene Fluoride fittings shall be manufactured from virgin Kynar® resin material, unpigmented and translucent. Fittings 1/2" (20mm) through 2 1/2" (75mm) shall be manufactured to have a pressure rating of 232 psi when measured at 68° F (20° C). Fittings shall be manufactured and catalogued for Socket, BCF (Bead and Crevice Free), IR® (Infrared) joining methods.
- 4. All components of the pipe and fitting system shall conform to the following applicable ASTM Standards, D3322, D 638, D2837, D2122, FM 4910 and shall conform to FDA CFR 21 177.1520 (certificate of conformance to be included with shop drawing submittal), USP 25 Class VI (certificate of conformance to be provided with shop drawing submittal) and ASME-BPE. All pipe and fittings shall be marked with brand name, product description, code number, material, and dimension and pressure rating information.

Fittings shall be embossed with a permanent identification during the production process to ensure full traceability.

5. In addition to the information specified under Paragraph C above, the printed pipe stream on extruded material shall be clearly marked "E84 UL CLASSIFIED SEE CERTIFICATE" which shows conformance and certification to ASTM E84/UL 723 for installation within designated return air plenum areas.

2.4 TRANSITION FITTINGS

- A. Transition Fittings: Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.5 PVDF VALVES

A. PVDF Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Asahi/America.
 - b. Georg Fischer Inc.
 - c. NIBCO INC.
 - d. Orion Fittings; a Watts Water Technologies company.
 - e. Plast-O-Matic Valves, Inc.
 - f. Thermoplastic Valves, Inc.
2. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating: 150 psig at 73 deg F.
 - c. Body Material: ASTM D 3222, PVDF resin.
 - d. Body Design: Union type.
 - e. End Connections: Detachable butt.
 - f. Ball: ASTM D 3222, PVDF resin.
 - g. Port: Full.
 - h. Seats: PTFE.
 - i. Stem: ASTM D 3222, PVDF resin.
 - j. Stem Seals: FKM-rubber O-rings.
 - k. Handle: Tee shaped.

B. PVDF Ball-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Asahi/America.
 - b. Georg Fischer Inc.
 - c. Legend Valve & Fitting, Inc.
 - d. NIBCO INC.
 - e. Thermoplastic Valves, Inc.

2. Description:

- a. Pressure Rating: 150 psig at 73 deg F.
- b. Body Material: ASTM D 3222, PVDF resin.
- c. Body Design: Union type.
- d. End Connections: Detachable infrared (IR) spigot.
- e. Ball: ASTM D 3222, PVDF resin.
- f. Seat and Seals: FKM-rubber O-rings.

C. PVDF Swing-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. American Valve, Inc.
- b. Asahi/America.
- c. Thermoplastic Valves, Inc.

2. Description:

- a. Pressure Rating: 150 psig at 73 deg F.
- b. Body Material: ASTM D 3222, PVDF resin.
- c. Body Design: Bolted-bonnet type.
- d. End Connections: Flanged.
- e. Shaft: ASTM D 3222, PVDF resin.
- f. Disc and Arm: ASTM D 3222, PVDF resins.
- g. Gasket and Seals: FKM rubber.

D. PVDF Diaphragm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. American Valve, Inc.
- b. Asahi/America.
- c. Georg Fischer Inc.
- d. NIBCO INC.
- e. Thermoplastic Valves, Inc.

2. Description:

- a. Pressure Rating: 150 psig at 73 deg F.
- b. Body Material: ASTM D 3222, PVDF resin.
- c. Body Design: Bolted-bonnet type.
- d. End Connections for NPS 2 and Smaller: Detachable infrared (IR) spigot..
- e. Diaphragm: FKM rubber.
- f. Seals: FKM-rubber O-rings.
- g. Handle: Wheel type.

E. Basis of design for the PVDF piping, fittings, valves, installation, etc. is SYGEF as manufactured by Georg Fischer Inc.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for removal of ceiling panel, and coordinate with other services occupying that space.
- F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- G. Install piping to permit valve servicing.
- H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

- A. System components shall be installed using the IR® (Infrared) joining methods according to current installation instructions as delivered in print or documented online at www.gfpiping.com.
- B. An on site installation seminar shall be conducted by GF personnel who are certified to conduct said seminar. Seminar topics shall include all aspects of product installation (storage, set up,

support spacing, fusion process, machine care, testing procedure, etc.). At the conclusion of the seminar, all installers will be given a written certification test and will be required to prepare and complete one fusion joint of the type being implemented on the project. Upon successful completion of said test, the installer will be issued a certification card verifying that they have met the requirements of the manufacturer with regards to knowledge of proper product installation and testing methods.

- C. Only the following GF Piping Systems LLC fusion units may be used to install the Sygef® Standard piping system:
 - 1. For IR Fusion Installation – IR63Plus® Infrared Butt Fusion Machines
- D. Under this specification, the contractor shall be responsible for the purchase or rental of the proper machine required to meet the intent of the specification and be used for installation of the product on site.
- E. Installer shall ensure that all pipe and fittings used for Pure Water Piping are components of the same system. No mixing of various manufacturers pipe and or fittings shall be allowed.
- F. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
- G. PVDF Piping Heat-Fusion Joints: Make according to ASTM D 2657.
- H. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 VALVE INSTALLATION

- A. Install sectional valves close to mains on each branch and riser serving equipment.
- B. Install shutoff valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.
- E. Install plastic valves of the same material as the plastic pipe in which they are installed.
- F. Install valves in horizontal piping with stem at or above center of pipe.
- G. Install valves in position to allow full movement of stem and lever handle.
- H. Install ball-check valves in horizontal or vertical position so ball will unseat during normal flow.
- I. Install swing-check valves in horizontal position with the hinge pin level.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- C. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1/2 and Smaller: 30 inches with 3/8-inch rod.
 - 2. NPS 3/4 to NPS 1-1/2: 36 inches with 3/8-inch rod.
- D. Install supports for vertical PVDF piping NPS 1-1/2 every 48 inches and NPS 2 and larger every 72 inches.
- E. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- F. Support vertical piping and tubing at base and at each floor.
- G. Rod diameter may be reduced one size for double-rod hangers, to minimum 3/8 inch.
- H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- C. Connect deionized-water piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Test piping, for leaks and defects.
 - 1. Schedule tests and their inspections by Owner, with at least 24 hours' advance notice.
 - 2. Do not cover piping or put into service before inspection and approval.
 - 3. Test completed piping according to Owner. If Owner does not have published procedures, perform tests as follows:

- a. Hydrostatic Tests: Test piping at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 100 psig.
4. Replace leaking joints with new materials and retest until no leaks exist.
5. Submit separate reports for each test.

3.8 CLEANING

- A. Use procedures prescribed by Owner or, if not prescribed, use procedures described below:
 1. Before using, purge.
 2. Clean piping by flushing with deionized and reverse-osmosis water or as recommended by the system manufacturer.

3.9 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.
- B. Deionized-Water Piping: Use the following piping materials for each pipe size range:
 1. NPS 3 and Smaller: PVDF pipe and fittings and heat-fusion joints.

3.10 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 1. Shutoff Duty: Install diaphragm valves in piping.
 2. Throttling Duty: Install diaphragm valves in piping NPS 3 and smaller.

END OF SECTION 226700

INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 230100 – BASIC MECHANICAL REQUIREMENTS

Article	Title	Page
PART 1	GENERAL.....	1
1.1	REFERENCES	1
1.2	GENERAL REQUIREMENTS.....	1
1.3	SCOPE OF WORK.....	2
1.4	DESCRIPTION OF SYSTEMS	2
1.5	SUBSTITUTIONS	3
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	3
1.7	LIST OF MATERIAL AND EQUIPMENT	5
1.8	MATERIALS AND WORKMANSHIP	5
1.9	CONTRACTOR'S SUPERVISION AND SUBCONTRACT WORK	5
1.10	COORDINATION.....	5
1.11	SITE OBSERVATION	6
1.12	PERMITS AND INSPECTIONS	6
1.13	TRADE AND LOCAL PRACTICES	6
1.14	PUBLIC UTILITIES.....	7
1.15	CUTTING AND PATCHING.....	7
1.16	ORAL INSTRUCTIONS.....	7
1.17	LEED-NC 2.2 EQ CREDIT 3.1 CONSTRUCTION IAQ MANAGEMENT PLAN DURING CONSTRUCTION	7
1.18	LEED-NC 2.2 EQ CREDIT 3.2 CONSTRUCTION IAQ MANAGEMENT PLAN BEFORE OCCUPANCY.....	8
1.19	RECORD DRAWINGS	9
1.20	MAINTENANCE MANUALS	10
1.21	FINAL OBSERVATION	10
1.22	ALTERATIONS AND DEMOLITION OF FACILITIES.....	11
1.23	GUARANTEE	12
1.24	SUBMITTAL SUMMARY	12
PART 2	PRODUCTS (NOT USED).....	12
PART 3	EXECUTION (NOT USED).....	12

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SECTION 230100 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCES

- A. Applicable provisions of GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS, SPECIAL CONDITIONS and sections in Division 01, GENERAL REQUIREMENTS, govern work under this specification division.
- B. Work installed shall be in strict compliance with governing codes and regulations. Installation shall be in accordance with recommendations and details provided by product manufacturers unless exceeded in quality by these specifications. Work called for in specifications or shown on drawings deemed contrary to code requirements should be brought to attention of Engineer prior to rough in for clarification or revision.

1.2 GENERAL REQUIREMENTS

- A. See Division 01.
- B. WTA Computer Aided Design (CAD) Drawings in Electronic Format:
 - 1. Computer Aided Design (CAD) drawings in electronic format when provided under this contract shall be for the convenience of the recipient only. The CAD drawings were prepared as William Tao & Associates, Inc. internal working documents. Depending on how the drawings are utilized and reassembled the resulting CAD drawings may be incomplete, contain inaccuracies or be in part obsolete. Therefore, William Tao & Associates, Inc. makes no representation as to its completeness, currency or accuracy.
 - 2. The user is advised that any translation of CAD drawings from one computer system or environment to another can and often does result in the loss of important data. This loss can include but may not be limited to: portions of text and dimensions - the existence, location or scale of symbols or other elements of graphics - the internal structure of the data including layers and data attributes - the style or weight of lines. William Tao & Associates, Inc. makes no representations as to the usability of this CAD data on any system.
 - 3. The user is further warned that, while all digital CAD data appears to be extremely accurate, this apparent accuracy is an artifact of the techniques used to generate it and is in no way intended to imply actual accuracy. The user of this data takes full responsibility for the accuracy and correctness of all measurements, areas, inventories, etc. extracted from this data either manually or with the use of a computer.
- C. First-Named Manufacturer:
 - 1. First-named manufacturer's device, equipment or system has been used in specifications and drawings to meet the job requirements and to determine the space and dimensional requirements. Verify that devices, equipment, systems or products by other than the first-named manufacturer used as basis for proposal will meet the job requirements and will fit the allocated space.
 - 2. Listing of a manufacturer as acceptable does not in any way relieve the Contractor from the responsibility for providing a device, equipment or system that meets the requirements of the specifications.
 - 3. No extra cost will be allowed due to effect on other trades when bid is based on products other than first-named manufacturer. Contractor shall be responsible for coordination required for the use of substituted devices, equipment, systems, or products by other than the first-named manufacturer.
- D. Drawing Details: Since the installation of devices, equipment and systems may vary by each manufacturer and the "approved manufacturer" for the job was unknown at the time the drawing details were made, the details shown on the drawings are to be accepted by the Contractor as general in nature and are not to be used for the installation. Contractor shall obtain from the

"approved manufacturer" of the devices, equipment or systems detailed installation drawings for their proper installation.

- E. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter. Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.
- F. Submission of shop drawings will be considered as indicating that space requirements have been reviewed and that submitted equipment will fit space allocated with due concern given to access required for maintenance purposes.
- G. Contract drawings and specifications are complementary and what is called for by one shall be as binding as if called for by both.
- H. Contractor shall furnish all labor and material required to complete installation of system including accessories, fittings, auxiliaries, and components required for proper performance of systems.
- I. "Provide" as called for in the specifications or on the drawings shall mean, "furnish and install."
- J. Location of Equipment, Ductwork, Piping, and Devices:
 - 1. Locations of the mechanical equipment and devices shall be determined by checking the Architectural Drawings, field measurements or the approved shop drawings.
 - 2. Relocate equipment, ductwork, piping, or devices when directed by Architect/Engineer without cost, providing equipment has not been installed and new location is not greater than 10 ft. from location shown.
- K. Do not scale drawings. Refer to Architectural and Structural Drawings for new and existing building construction, dimensions and finishes in order to provide proper rough-in and installation of work.
- L. Quality Control:
 - 1. Exposed Work in Finished Spaces: Install devices and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed. Piping required to be sloped shall be installed correctly.
 - 2. Equipment Access: Install devices and equipment to facilitate servicing, maintenance and repair or replacement. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.
 - 3. Cleanliness: Contractor shall keep debris and dirt from around, on top of and the inside of all electrical equipment he provides during construction.

1.3 SCOPE OF WORK

- A. Provide labor, material, mounting hardware, terminations, tools, transportation, services, and equipment necessary to provide complete and operating systems for work specified in Division 23. See individual sections for scope of work and Division 01.
- B. Provide commissioning as specified in Section 019113 - GENERAL COMMISSIONING.
- C. See Division 01, LEED REQUIREMENTS for requirements including but not limited to construction IAQ management plan.

1.4 DESCRIPTION OF SYSTEMS

- A. See individual sections of Division 23 for general description of required mechanical systems, equipment, devices, and products.

1.5 SUBSTITUTIONS

- A. See Division 01.
- B. Reference related Division 23 sections of specifications for additional requirements.
- C. Submit to Architect/Engineer a typed list of substitutes proposed to be used in lieu of device, equipment or system named in specifications or drawings with a request for approval of the proposed substitutes. List and written requests with detailed information shall be delivered to office of Architect/Engineer not later than 10 days prior to bid due date to be considered. Submittal shall include following:
 - 1. Specific device equipment or system proposed for substitution giving manufacturer, catalog and model number.
 - 2. Performance and dimensional data necessary for comparison of proposed substitute with equipment or material specified.
- D. If the Contractor does not provide the written request for substitutions, the Contractor shall provide one of the listed manufacturers in the specifications or on the drawings. Refer to article entitled "List of Material and Equipment" for additional requirements.
- E. Samples shall be provided when requested by Engineer. Samples shall be delivered to office of Engineer with transportation charges prepaid. Supplier will be notified and shall cause sample to be removed from office of Engineer in unpacked condition at completion of Engineer's examination of product. Samples not removed after 30 days will be discarded.
- F. Addenda for proposed substitutes, which are found to be acceptable, will be issued by Architect/Engineer. Architect/Engineer reserves rights to reject substitutes, which are inferior in quality, capacity or design, or which adversely affect overall concept. Decision of Architect/Engineer shall be final.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Division 01, LEED REQUIREMENTS for preliminary submittal, progress reports and submittal documentation requirements.
- B. LEED-NC 2.2 EQ Credit 3.1: Submit project photographs documenting the Indoor Air Quality (IAQ) Management Plan practices implemented. A minimum of eighteen (18) total photographs shall be submitted, six (6) photographs taken at three (3) separate times during construction. Each photograph shall be labeled with the IAQ Management Plan approach being implemented in the photograph.
- C. LEED-NC 2.2 EQ Credit 3.2: Submit the project's Construction IAQ Management Plan documenting the appropriate pre-occupancy phase compliance path:
 - 1. Option 1a: Building Flush-Out Prior To Occupancy: Provide a detailed narrative describing the project's pre-occupancy flush-out process. Include data regarding temperature, airflow, and duration of flush-out including any special considerations.
 - 2. Option 1b: Building Flush-Out with Early Occupancy: Provide a detailed narrative describing the project's pre-occupancy and post-occupancy flush-out process. Include data regarding airflow and duration of flush-out including any special considerations.
 - 3. Option 2: Indoor Air Quality (IAQ) Testing: Submit the project's IAQ testing report. Provide a detailed narrative describing the project's pre-occupancy and post-occupancy flush-out process. Include data regarding airflow and duration of flush-out including any special considerations.
- D. Shop drawings shall be submitted in accordance with Division 01, SHOP DRAWINGS and related articles of GENERAL CONDITIONS and with the requirements of this article.
- E. See article entitled Submittal Summary and detailed shop drawing requirements in other sections of Division 23. Submittal transmittal shall reference specification section and description of equipment. Submittals shall be clearly scheduled and marked as to which model number, quantity and type is being submitted. Copies of catalog cut sheets are not sufficient

unless clearly defined project specific information is marked. All shop drawings submitted shall include the WTA Project Number and Project Name that is given in the drawing title block. Shop drawings that are resubmitted shall be noted as resubmittals and shall be given same WTA log number, as original submittal, suffixed by A or B as applicable. Shop drawing shall include the specification section that the submittal item is referencing. Each specification section shall be submitted as a single submittal, otherwise will be rejected.

- F. Contractor must allow 2 weeks for Engineers to review and process the shop drawings. Detailed shop drawing items such as temperature controls shall require 4 week review and process time. Shop drawings shall be phased and submitted in a sequence, which allows adequate time for Engineer review. Submittal of large numbers of shop drawings simultaneously is discouraged and may result in time for review, which exceeds the normal 2 week commitment for return. Any effect on construction schedule due to untimely submittal of shop drawings shall be the responsibility of the Contractor. Contractor shall submit Mechanical Submittal Summary within 2 weeks of being awarded the contract.
- G. All shop drawings shall be submitted in a legible manner. Submittals shall be original or first generation. Any submittals that have been recopied to the point of illegible status will be rejected. Submittals must be in PDF format.
- H. All electronic shop drawing submittals shall be emailed to "wtashop@wmtao.com Attention: Sara Trout." Please include password/rights when sending shop drawings to wtashop if done through an informational exchange site.
- I. Shop drawings and product data of standard cataloged products shall be submitted with schedules of equipment and with applicable data included in schedule. Submittals that include information on multiple devices or equipment are acceptable only when items applicable to the job are identified with arrows, check marks or other call outs. Schedules shall be submitted in legible form as stated above. Schedules shall be not less than double spaced to allow for corrections by Engineer. Manufacturer's submitted literature, catalogs or bulletins covering equipment shall be submitted with schedules in quantity called for under Division 01 and GENERAL CONDITIONS. Printed material shall also be included in Maintenance Manual.
- J. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter. Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.
- K. Shop drawings are required for equipment, material and devices scheduled in Submittal Summary. Shop drawings of related equipment, devices and material shall be submitted at same time so Architect/Engineer can coordinate related components.
- L. Incomplete submittals and submittals not in accordance with above paragraphs will be returned without action, and resubmittal will be required.
- M. Corrections or modifications made by Architect/Engineer shall be deemed acceptable with no change in contract amount unless written notice is received by Architect/Engineer prior to performance of work affected by corrections or modifications.
- N. Review and stamp shop drawings in accordance with requirements of General Conditions prior to submittal to Architect/Engineer. Shop drawings without Contractor's stamp will be returned without checking.
- O. No material or equipment shall be released for manufacture or shipment without first obtaining Architect/Engineer's approved shop drawings.
- P. When shop drawings are created from or incorporated with the Engineer's CAD drawings, the Contractor shall remove the Architect and Engineer's title block and reinsert the Contractor's title block. The new title block shall include the Contractor's name, address and telephone

number, the project name and the name of the Architect/Engineer of record. Reference preceding GENERAL REQUIREMENTS Article 1.2 in this Section for the contents of the CAD drawings in electronic format provided by WTA.

- Q. Submittal Summary: See SUBMITTAL SUMMARY article at end of this section.

1.7 LIST OF MATERIAL AND EQUIPMENT

- A. Submit List of Material and Equipment within 2 calendar weeks after award of contract by Owner. Provide six (6) copies to Architect/Engineer for approval of manufacturers of material and equipment proposed for project.
- B. Approval of List of Material and Equipment will be subject to submission and review of shop drawings.
- C. Provide first-named manufacturer for material and equipment on project if "List of Material and Equipment" is not received by Architect/Engineer within prescribed time limit, or if specified equipment or material is not listed on submitted list.

1.8 MATERIALS AND WORKMANSHIP

- A. Material and equipment required under this contract shall be new unless otherwise specified. Workmanship shall be first class and be performed by persons qualified in respective trades.
- B. Material shall meet requirements of governing codes and regulations.
- C. Mechanical material and equipment, where applicable, shall be UL listed.

1.9 CONTRACTOR'S SUPERVISION AND SUBCONTRACT WORK

- A. Work shall be under constant supervision of qualified superintendent or foreman.
- B. Submit name of major subcontractors to Architect/Engineer for approval prior to award of subcontract work. Architect/Engineer reserves right to approve or disapprove major subcontractors, such as piping, sheet metal, insulation, automatic control, and specialty work.
- C. Job superintendents or foremen shall not be changed without prior notice to and approval of Architect/Engineer in order to maintain proper coordination and continuity of branches of work.

1.10 COORDINATION

- A. Coordinate work to eliminate interferences. Interferences due to lack of coordination shall be corrected to provide proper clearance and access with costs borne by Contractor. Ductwork, piping, etc. shall not be hung from electrical boxes, conduit, busway or hangers supporting boxes, conduit or busway. Install mechanical systems giving right-of-way where space is available to systems such as plumbing, drain, and fire protection lines required to be installed at a specified slope.
- B. Adequate clearance shall be maintained to allow for access, repairs and removal of devices. Protect installation from being obstructed by other Contractors.
- C. Contractors shall prepare drawings for installation of equipment, ductwork, piping, devices and systems as required by Division 01 to coordinate work. This specifically includes mechanical work in the existing East Academic Building and Lower Level Equipment Room, tight ceiling cavities in areas of medium velocity supply ductwork, cable tray runs, and piping, but does not exclude other areas. Joint coordination drawings by Contractors shall be prepared as joint effort to coordinate installation of work by affected trades. These drawings are not to be submitted to the Architect/Engineer for approval.
- D. Permanent openings or knockout panels shall be provided to permit future service or replacement of system components or complete unit replacement. Coordinate equipment delivery with construction progress in order that installation may be made in orderly and safe manner.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- E. Contractor shall make arrangements for hoisting equipment and shall assume all related cost. Routes used by hoisting vehicles and vehicle parking shall be approved by Owner prior to their use.
- F. Building structure is designed for supporting equipment at its permanent location. Provide necessary shoring or other protection necessary for moving heavy equipment to permanent location.
- G. Top elevations indicated for catch basins, manholes, pits and grade shall be considered approximate only. Coordinate final grades and elevations prior to installation and completion of work affected by final grade elevations. Work installed which does not meet finished grades shall be adjusted at no increase in contract amount.
- H. Contractor shall coordinate his equipment delivery with construction progress so that installation may be made in an orderly and safe manner.

1.11 SITE OBSERVATION

- A. Visit site prior to preparation of bid and determine conditions that affect execution of work.
- B. Location and elevation of existing, underground, or visible utilities, such as sewers, electrical power, water piping and conduit are as exact as can be determined from available information and their accuracy cannot be guaranteed. Exact location and elevation of these services shall be verified by Contractor prior to excavation or installation of work. Exercise special care when excavating at or near general location of underground utilities to avoid damage to utility services, as well as to assure safety.
- C. Connections to or relocation of existing utility lines requiring temporary discontinuation of utility services, which are in active use shall be scheduled and coordinated with utility companies and representatives of Owner. Premium time required for installation of connections and relocations shall be included in bid. Services shall not be left disconnected at end of working day or weekend unless authorized by representatives of utilities and Owner. Existing utility services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.
- D. Failure to be acquainted with existing conditions under which work is to be performed will not be justification for additional compensation.
- E. Missouri 1-800-DIG-RITE: Missouri law requires the Contractor to call Missouri One Call System Inc. (MOCS) not more than 10 days in advance of any excavation activity unless it's an emergency situation involving danger to life, health or property. Notify Owner for location of private utilities.

1.12 PERMITS AND INSPECTIONS

- A. Obtain required permits governing the contract work from Authorities Having Jurisdiction and assume cost of permits and inspections.
- B. Furnish to Owner certificates of inspection or approval from Authorities Having Jurisdiction, if certificates of inspection or approval are required by law or regulations, upon completion of work.
- C. Contractor shall assume the cost of labor and materials including smoke bombs to conduct all required acceptance test required by local jurisdiction including smoke control test, fire alarm interface test, sprinkler system testing and any other testing required by local authorities.

1.13 TRADE AND LOCAL PRACTICES

- A. Comply with local customs and labor trade agreements, which determine particular trade or trades that shall be employed for installation of work.

1.14 PUBLIC UTILITIES

- A. Utility services shall be installed in strict accordance with standards of Utility Companies or Public Utility Agencies. Customer contribution, if required, shall be assumed by Contractor.

1.15 CUTTING AND PATCHING

- A. See Division 01.
- B. General: Structural members, load-bearing walls or footings shall not be cut without first obtaining written permission from Architect/Engineer. Openings not properly provided by sleeves and framed openings shall be cut.
- C. Cutting:
 - 1. Openings for pipe in masonry materials shall be core drilled. Other openings shall be cut as necessary. See Section 230500, SLEEVES AND OPENINGS article.
 - 2. Make thorough investigation and field measurement by use of magnetic detection instruments or other approved means to detect any concealed ferrous metal piping or conduit prior to cutting. Active piping, conduit or wire damaged due to this work shall be restored immediately. Restoration costs shall be at expense of Contractor.
 - 3. Cutting shall be limited to size necessary for working conditions. Consult with Contractor responsible for finish work and jointly develop method of cutting when surfaces are difficult or costly to replace, such as marble, glazed tile and wood paneling.
- D. Patching and Finishing:
 - 1. Patching:
 - a. Concrete or Concrete Block Surfaces: Patch opening with grout finished smooth with adjacent surface prior to applying final finish.
 - b. Gypsum Board or Plastered Surfaces: Patch opening with filler compound finished smooth with adjacent surface prior to applying final finish.
 - c. Special Finished Surfaces: Patch openings with appropriate material where surfaces are to have finishes such as tile, paneling, stone or marble finish.
 - d. Painted Surfaces: Patch the opening smooth with adjacent surfaces.
 - 2. Finishing: Final finish shall match adjacent surface and shall be responsibility of Contractor requiring cutting when final finish has been applied prior to cutting and where existing surfaces are cut. Contractor shall be totally responsible for quality of finish work and shall make corrections in final finish to maintain quality of finish to match existing.

1.16 ORAL INSTRUCTIONS

- A. See Division 01.
- B. Assign responsible person who is thoroughly familiar with installed systems to give verbal instructions to Owner's assigned operating personnel whenever systems are turned over to Owner for operation. Video document instructions and provide digital copy to Owner.
- C. Direct specific instructions by factory-trained representatives shall be provided for following equipment and systems in addition to above general instructions.
 - 1. Heating plant
 - 2. Water treatment
 - 3. Automatic control systems
 - 4. Specialty systems (and equipment)

1.17 LEED-NC 2.2 EQ CREDIT 3.1 CONSTRUCTION IAQ MANAGEMENT PLAN DURING CONSTRUCTION

- A. Develop and implement an IAQ Management Plan for the construction and pre-occupancy phases of the building following the recommended design approaches in SMACNA IAQ Guideline for Occupied Buildings Under Construction, 1995, Chapter 3.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Protect stored on-site or installed materials from moisture damage.
 - C. Filtration media shall be used for all air handling systems operated during construction as described in Section 235000.
- 1.18 LEED-NC 2.2 EQ CREDIT 3.2 CONSTRUCTION IAQ MANAGEMENT PLAN BEFORE OCCUPANCY
- A. Develop and implement an Indoor Air Quality (IAQ) Management Plan for the pre-occupancy phase as follows:
 - 1. Option 1a: Building Flush-Out Prior to Occupancy: After construction ends, prior to occupancy and with all interior finishes installed, perform a building flush-out by supplying a total air volume of 14, 000 cu.ft. of outdoor air per sq.ft. of floor area while maintaining an internal temperature of at least 60 deg. F. and relative humidity no higher than 60 percent.
 - 2. Option 1b: Building Flush-Out with Early Occupancy: If occupancy is desired prior to completion of the flush-out, the space may be occupied following delivery of a minimum of 3,500 cu.ft. of outdoor air per sq.ft. of floor area to the space. Once a space is occupied, it shall be ventilated at a minimum rate of 0.30 cfm/sq.ft. of outside air or the design minimum outside air rate determined in EQ Prerequisite 1, whichever is greater. During each day of the flush-out period, ventilation shall begin a minimum of 3 hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 14,000 cu.ft./sq.ft. of outside air has been delivered to the space.
 - 3. Option 2 - Air Quality Testing:
 - a. Conduct baseline IAQ testing, after construction ends and prior to occupancy, using testing protocols consistent with the United States Environmental Protection Agency Compendium of Methods for the Determination of Air Pollutants in Indoor Air and as additionally detailed in the LEED 2.2 Reference Guide.
 - b. Demonstrate that the contaminant maximum concentrations listed below are not exceeded.

Contaminant	Maximum Concentration
Formaldehyde	50 parts per billion
Particulates (PM10)	50 micrograms per cubic meter
Total Volatile Organic Compounds (TVOC)	500 micrograms per cubic meter
Carbon Monoxide (CO)	9 parts per million and no greater than 2 parts per million above outdoor levels

- c. For each sampling point where the maximum concentration limits are exceeded conduct additional flush-out with outside air and retest the specific parameter(s) exceeded to indicate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting non-complying building areas, take samples from the same locations as in the first test.
- d. The air sample testing shall be conducted as follows:
 - 1) All measurements shall be conducted prior to occupancy, but during normal occupied hours, and with the building ventilation system starting at the normal daily start time and operated at the minimum outside airflow rate for the occupied mode throughout the duration of the air testing.
 - 2) The building shall have all interior finishes installed, including but not limited to millwork, doors, paint, carpet and acoustic tiles. Non-fixed furnishings such as workstations and partitions are encouraged, but not required, to be in place for the testing.
 - 3) The number of sampling locations will vary depending upon the size of the building and number of ventilation systems. For each portion of the building served by a separate ventilation system, the number of sampling points shall not be less than 1 per 25,000 sq.ft., or for each contiguous floor area,

- whichever is larger, and include areas with the least ventilation and greatest presumed source strength.
- 4) Air samples shall be collected between 3 ft. and 6 ft. from the floor to represent the breathing zone of occupants, and over a minimum 4 hour period.

1.19 RECORD DRAWINGS

- A. Contractor shall provide Record Drawings to Owner within 90 days after the date of system acceptance.
- B. See Division 01.
- C. Contractor shall keep day-to-day record of installed locations and changes in sizes of the following:
1. Piping concealed in walls, floors, underground, or above inaccessible ceilings. Record need not include exposed piping or piping above removable ceilings.
 2. Ducts concealed in walls, underground or above inaccessible ceilings.
 3. Volume and fire dampers, smoke dampers and access panels both exposed and concealed.
 4. Pull and junction boxes for automatic control systems.
 5. Underground waste and soil lines inside building.
 6. Underground sewers, piping, conduit, and utilities exterior of building.
- D. Underground utility services, both inside and outside of buildings, shall be dimensioned from permanent structures or benchmark. Utility services outside of buildings shall show depth of burial or flow line with reference to finished ground floor elevation.
- E. Contractor shall obtain a set of drawing prints of the Contract Drawings pertaining to his work immediately upon commencing work on project. This set of drawings shall be kept at the project site at all times and be used by the Contractor for manually recording the changes in the Contract Drawings. These drawings shall be kept as clean as possible and all marks for record purposes shall be legible. This will help the Contractor in the preparation of Record Drawings. Should a single print or drawing become crowded or unclear due to excessive changes at any time prior to the completion of the project, the Contractors shall obtain a second copy of the same drawing and make additional manual recordings as necessary. Both drawings shall be retained at the job site.
- F. CAD Drawings: One set of Engineering Contract Document drawings in electronic format will be issued to the Construction Manager or General Contractor at start of construction. One additional set of Engineering Drawings in electronic format will be issued to the Construction Manager or General Contractor prior to date of Substantial Completion. Reference previous GENERAL REQUIREMENTS Article 1.2 for the contents of the CAD drawings in electronic format provided by WTA. Any copies of these documents requested by the Contractors or subcontractors shall be provided by the Construction Manager or General Contractor. Contractor shall transfer the projects record conditions recorded on job site prints, as outlined above, to the CAD drawings. No other electronic file updates will be provided by the Architect/Engineer.
- G. Contractor shall obtain a copy of CAD drawings in electronic format from WTA on a disk. Reference previous GENERAL REQUIREMENTS Article 1.2 for contents of CAD drawings provided by WTA. Contractor shall use this disk to prepare record drawings. Record drawings shall be made by using AutoCAD 2010-11 compatible system and deliver disk plus one set of reproducible drawings and two (2) sets of full size drawings and pdf files to Architect/Engineer for approval prior to authorization for final payment. Record drawings shall be certified as to their correctness by signature of Contractor and shall be stamped or otherwise identified as "Record Drawings."
- H. When final revisions have been completed by the Contractor, the cover sheet drawing shall show the wording "RECORD DRAWINGS" followed by the name of the authenticating

Contractor and project completion date in letters minimum 1/8 inch high. The Contractor shall mark all other contract drawings "RECORD DRAWINGS" along with a stamp/signature and project completion date in the specified authentication area provided on each drawing.

- I. MSD will require seal of surveyor or Engineer who prepared Record Drawings. Seal of Design Engineer shall not appear on MSD submittals.

1.20 MAINTENANCE MANUALS

- A. Contractor shall provide maintenance manuals to Owner within 90 days after the date of system acceptance.
- B. See Division 01.
- C. General: Contractor shall provide three (3) hard copy volumes of Maintenance Manuals and a CD of all material submitted at completion of project. Manuals shall be provided one week prior to Contractor's request for final inspection.
 1. Startup and Shutdown Procedures: Provide step-by-step write up of major equipment. Incorporate manufacturer's printed startup, troubleshooting and shutdown procedures.
 2. Equipment List: List of major equipment as installed shall include model number, capacities, flow rates, and nameplate data.
 3. Service Instructions: Provide following information for pieces of equipment:
 - a. Recommended spare parts including catalog number and name, address and telephone number of local suppliers or factory representatives.
 - b. Lubrication and maintenance instructions for equipment including electric motors.
 - c. Belt sizes, types and lengths.
 4. Include in manuals, parts catalogs for items of equipment furnished with components identified by number for replacement ordering.
- D. Submission:
 1. Manuals shall be in triplicate, and materials shall be bound into volumes of standard 8-1/2 inch by 11 inch hard binders. Large drawings too bulky to be folded into 8-1/2 inch by 11 inch size shall be separately bound or folded into brown envelopes, cross-referenced and indexed with manuals. A CD shall be included with all material submitted.
 2. Manuals shall include name of Architect/Engineer, Contractors and major subcontractors.
 3. It is suggested that Contractor submit one preliminary copy of manual to Engineer for precheck; and when approved, shall submit three (3) final hard copies and three (3) CD through normal channels.

1.21 FINAL OBSERVATION

- A. Contractor shall review requirements of contract documents, observe work and inform parties involved of work to be corrected or completed before project can be deemed substantially complete.
- B. Notify Architect/Engineer in writing, when project is substantially complete listing those items of work remaining incomplete and anticipated date that remaining work will be completed. Final observation of project will then be scheduled by the Architect/Engineer.
- C. The Architect/Engineer reserves the rights to cancel and reschedule the observation in the event considerably more work remains to be completed or corrected than was indicated in the written request for observation.
- D. A representative of the Contractor shall be present at the time of observation.
- E. Items not completed or found not complying with drawings or specifications by the Architect/Engineer will be identified in the observation report.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- F. A copy of the report will be given to the Contractor. Deficient items on observation report shall be corrected. The Contractor shall initial and date items on report after corrections have been completed.
- G. The Architect/Engineer will make final check after items have been corrected. The Contractor shall be present during final check and shall verify that corrections have been made.

1.22 ALTERATIONS AND DEMOLITION OF FACILITIES

A. General:

- 1. It shall be recognized that while work for general construction is confined to certain floor areas of building, work for mechanical systems may have to be extended to include other floors or areas in order that systems may be installed. Plan work in advance and obtain permission from Architect/Engineer and Owner for work that shall be performed in other floors or areas so that areas affected may be vacated or otherwise prepared by Owner. Interruption of other areas or floors shall be kept to minimum.
- 2. Temporary connections shall be provided when extended interruptions of services and utilities, such as water, waste, duct systems, electrical power, and controls, which serve other areas, are necessary.
- 3. Make necessary provisions for protection of workers, other persons and property.
- 4. Assume following responsibilities upon removal of existing non-accessible ceilings and walls where existing piping or ductwork has been concealed.
 - a. Investigate as required and identify piping and ductwork as to their source and point of termination. Prepare a report for the Owner indicating the additional cost for performing the following work:
 - 1) Remove pipe and ductwork that are inactive or that will be inactive as result of project.
 - 2) Remove and relocate active piping or ductwork in path of and interfering with new construction or renovation work to maintain respective service. Coordinate and receive Owner approval before beginning work.
 - b. No additional compensation will be allowed for work that is exposed or above lay-in ceilings or in accessible shafts and chases that are accessible to the Contractor during the bidding period.
- 5. Check with maintenance personnel as to source of utilities and temporarily disconnect or shutoff services or utilities at nearest main. Temporary isolation valves shall be installed close to point of work.
- 6. It is essential that building operations continue essentially without interruption. It is necessary that operation of systems be interfered with as little as possible, except in areas vacated for construction work. Work which will interfere with operation of existing fire suppression, plumbing, heating, electrical power, and air conditioning systems, or which requires downtime, shall be scheduled only after consultation with and permission of Owner. Consultation shall be requested ten days prior to anticipated interruption of systems serving occupied areas. Work may be required to be performed during other than normal working hours.

B. Material and Equipment Removed From Service:

- 1. Major items of material and equipment in serviceable condition will be retained by Owner.
- 2. Equipment and material not claimed by Owner shall be property of Contractors and shall be removed from premises and disposed of at Contractor cost.
- 3. Material and equipment to be retained by Owner shall be stored at convenient location as directed by Owner.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1.23 GUARANTEE

A. General Guarantee:

1. Guarantee work against defects in labor and material for period of one year from date of Owner acceptance and Owner's takeover of equipment for use and maintenance.
2. Starting date of guarantee for defective or incomplete system or equipment shall become effective only after correction and completion.
3. Guarantee period for systems or equipment will begin from date of correction and completion if portion of building is occupied by Owner prior to completion of project and portion of mechanical and electrical systems or equipment must be accepted by Owner and turned over to Owner for operation and maintenance. Submit written certificate in triplicate listing such systems and equipment to Architect/Engineer for signature of Owner for record purposes. Certificate for partial use of systems or equipment will become effective after being countersigned by Owner.
4. Guarantee is not intended to cover damage resulting from Owner's misuse, normal maintenance, such as lubrication, belt adjustment or replacement.

- B. Specific Warranty:** See specific equipment specification for extended warranties. Provide manufacturer's warranty of subject equipment to Owner prior to receiving final payment where extended warranties are specified. Extended warranties shall cover labor, material and travel expenses to repair and place equipment in service.

1.24 SUBMITTAL SUMMARY

- A.** See the following Submittal Summary forms for detailed list of submittals.
- B.** See specification section for specific details of submittal requirements. Make copy of applicable forms and indicate estimated date of each submittal in column provided. Completed forms shall be submitted to Architect/Engineer through proper channels within 4 weeks after date of contract.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

MECHANICAL SUBMITTAL SUMMARY

Spec. Section No	Description of Submittal	Catalog Cuts	Wiring Diagrams	Schedule of Items	Maintenance Manuals	WTA Review Period (Weeks)	Sound Data	Contractor Estimated Submittal Date	Furnish as Submitted	Furnish as Noted	Revise and Resubmit	Rejected	Other
230100	Submittal Summary			X		2							
230100	Maintenance Manuals	X	X	X	X	4							
230100	LEED-NC 2.2 EQ 3.1 Construction IAQ Management Plan During Construction			X		2							
230100	LEED-NC 2.2 EQ 3.2 Construction IAQ Management Plan Before Occupancy			X		2							
230500	Firestop Materials	X		X		2							
230500	Access Panels	X		X		2							
230500	Electric Motors and Drives		X	X	X	2							
230500	LEED-NC 2.2 EQ 4.1 Low Emitting Materials, Adhesives and Sealants												
230500	LEED-NC 2.2 EQ 4.2 Low Emitting Materials, Paints and Coatings												
230600	Piping Materials	X		X		2							
230600	Mechanical Couplings	X		X		2							
230600	Valves	X		X		2							
230600	Piping Specialties	X		X	X	2							
230600	Gas Service	X		X		2							
230600	Gauges and Thermometers	X		X		2							
230600	LEED-NC 2.2 EQ 4.1 Low Emitting Materials, Adhesives and Sealants			X		2							
230600	Supports and Hangers	X		X		2							
231900	Piping Markers	X		X		2							
231900	Valve Tags	X		X		2							
231900	Nameplates	X		X		2							

MECHANICAL SUBMITTAL SUMMARY

Spec. Section No	Description of Submittal	Catalog Cuts	Wiring Diagrams	Schedule of Items	Maintenance Manuals	WTA Review Period (Weeks)	Sound Data	Contractor Estimated Submittal Date	Furnish as Submitted	Furnish as Noted	Revise and Resubmit	Rejected	Other
231900	LEED-NC 2.2 EQ 4.1 Low Emitting Materials, Adhesives and Sealants			X		2							
232400	Seismic Calculations, Details and Shop Drawings by Registered PE	X		X	X	4							
232400	Vibration Isolation	X		X	X	2							
232400	Seismic Restraints	X		X	X	2							
232500	Jacketing and Finishing	X		X		2							
232500	Pipe Insulation	X		X		2							
232500	Sheetmetal Work Insulation	X		X		2							
232500	Equipment Insulation	X		X		2							
235000	Air Handling Units	X	X	X	X	2	X						
235000	Boilers	X	X	X	X	2	X						
235000	Low Temperature Stack	X		X	X	2							
235000	Variable frequency Drives	X	X	X	X	2	X						
235000	Ductless Split Cooling System	X	X	X	X	2	X						
235000	Laboratory Exhaust Fans (Mixed Flow, Induced Dilution Type)	X	X	X	X	2	X						
235000	In-Line Centrifugal Fan	X	X	X	X	2	X						
235000	Ceiling Type Exhaust Fan	X	X	X	X	2							
235000	Roof Upblast Exhauster	X	X	X	X	2	X						
235000	Pumps	X	X	X	X	2							
235000	Unit Heaters	X	X	X	X	2							
235000	Cabinet Unit Heaters	X	X	X	X	2							
235000	Finned Tube Radiation	X		X	X	2							
235000	Heat Exchanger	X		X	X	2							

MECHANICAL SUBMITTAL SUMMARY

Spec. Section No	Description of Submittal	Catalog Cuts	Wiring Diagrams	Schedule of Items	Maintenance Manuals	WTA Review Period (Weeks)	Sound Data	Contractor Estimated Submittal Date	Furnish as Submitted	Furnish as Noted	Revise and Resubmit	Rejected	Other
235000	Glycol Solution and Pump System	X	X	X	X	2							
235000	Hot and Chilled Water Treatment	X		X	X	2							
238800	Flexible Ducts	X		X	X	2							
238800	Duct Lining	X		X	X	2							
238800	Sheet Metal Specialties	X		X	X	2							
238800	Backdraft Damper	X		X	X	2							
238800	Leakage Test			X	X	2							
238800	Air Distribution Devices	X		X	X	2							
238800	Louvers	X		X	X	2							
238800	Roof Relief and Intake Vents	X		X	X	2							
238800	Sound Attenuators	X		X	X	2	X						
238800	Single Inlet Air Terminal Unit with Heating Water	X	X	X	X	2	X						
238800	HVAC Casings	X		X	X	2							
238800	Supports and Hangers	X		X		2							
239500	Control Equipment and Devices	X	X	X	X	4							
239500	Laboratory Air Valves/Fume Hood Controls	X	X	X	X	4	X						
239500	Sequence of Control		X	X	X	4							
239900	Test and Balance Report		X	X	X	4							
	LEED-NC 2.2 Prerequisite 1 ASHRAE 62.1, Air Balancing			X		2							
239900	LEED-NC 2.2 EQ 4.2 Low Emitting Materials, Paints and Coatings			X		2							

END OF SECTION 230100

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INDEX

DIVISION 23 - MECHANICAL WORK

SECTION 230500 - BASIC MECHANICAL MATERIALS AND METHODS

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		2
2.1	SLEEVES AND OPENINGS	2
2.2	VOLATILE ORGANIC COMPOUND (VOC) CONTENT	2
2.3	INTERLOCKING LINK TYPE	2
2.4	FIRESTOPPING SYSTEM	2
2.5	ACCESS PANELS	2
2.6	ELECTRIC MOTORS AND DRIVES	3
2.7	PAINT, GENERAL	4
2.8	MAGNETIC MOTOR STARTER	4
PART 3 - EXECUTION		5
3.1	SLEEVES AND OPENINGS	5
3.2	ACOUSTICAL SEALS FOR PENETRATIONS OF ACOUSTICALLY SENSITIVE AREAS	7
3.3	LINTELS	7
3.4	ROOF OPENINGS AND CURBS	7
3.5	CONCRETE WORK	8
3.6	ACCESS TO EQUIPMENT	9
3.7	MECHANICAL COORDINATION FOR ELECTRICAL WORK	9
3.8	EXCAVATION AND BACKFILL	9
3.9	PAINTING	10

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SECTION 230500 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and all requirements of Section 230100 BASIC MECHANICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. See Section 230100.
- B. This section is intended to cover basic mechanical materials and methods and their installation applicable to Contractor's work.
- C. Contractor shall include all labor and material for complete mechanical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- D. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- E. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.
- F. Provide manufacturer's Seismic Certificate of Compliance for compliance with seismic requirements of International Building Code, Section 232400 and as required by Authorities Having Jurisdiction.

1.3 SCOPE OF WORK

- A. This specification section covers material and labor common to mechanical work covered under Division 23.

1.4 DESCRIPTION OF SYSTEMS

- A. See related specification sections for description of major segments of systems.

1.5 SUBSTITUTIONS

- A. See Section 230100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 230100.
- B. LEED Submittal:
 - 1. Product Data for Credit EQ 4.1: For adhesives, sealants and sealant primers, including printed statement of VOC content and chemical components.
 - 2. Product Data for Credit EQ 4.2: For interior paints, including printed statement of VOC content and chemical components.

PART 2 - PRODUCTS

2.1 SLEEVES AND OPENINGS

- A. Provide and locate sleeves and provide sealing. Provide openings for ducts and similar items not otherwise provided on Structural drawings. See PART 3 of this specification section for installation and sealing of sleeves.

2.2 VOLATILE ORGANIC COMPOUND (VOC) CONTENT

- A. VOC Content of Adhesives, Sealants, and Sealant Primers: Provide products that comply with the VOC limits as listed in South Coast Air Quality Management District (SCAQMD) Rule #1168, effective date July 1, 2005 and rule amendment date of January 7, 2005.
- B. VOC Content of Anti-Corrosive and Anti-Rust Paints Applied to Ferrous Metals: Provide products that comply with the limits for VOC content of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.

2.3 INTERLOCKING LINK TYPE

- A. Provide Thunderline Corporation or Calpico interlocking link type seals for sealing annular space between pipe and wall or between pipe and sleeve in exterior walls. Links shall be synthetic rubber; pressure plates, bolts, nuts and washers shall be stainless steel. Seals shall be suitable for watertight installation and shall withstand a hydrostatic pressure of 20 psi. Contractor shall have the option to use matching Schedule 40 steel sleeve as provided by seal manufacturer.

2.4 FIRESTOPPING SYSTEM

- A. See Division 07, FIRESTOPPING.

2.5 ACCESS PANELS

- A. General: Provide where required for access to devices. See PART 3 of this specification section.
- B. Construction:
 - 1. For Masonry, Tile or Wallboard Surfaces: 16 gauge steel frame, 16 gauge steel, 1 inch wide flange, 16 gauge steel panels, concealed hinges, screwdriver-operated cam lock, baked-enamel prime coat. Final painting to match interior decor as specified under Division 09. Panel shall be Milcor Style M. Access doors in tile walls shall be Milcor Type M, stainless steel.
 - 2. For Plastered Ceilings or Walls: Concealed flange, recessed door panel to receive plaster under general contract work, 16 gauge galvanized steel frame, 18 gauge galvanized steel panel, 3.4 gauge galvanized steel lath, continuous hinges, flush latch, white prime coat finish. Final painting to match interior decor as specified under Division 09, Milcor Type AP.
 - 3. For Fire-Rated Partition: Access doors in 2 hour fire-rated partitions shall be 1-1/2 hour B rated and shall bear the UL label. Doors shall be fabricated of steel and be provided with baked-enamel prime coat over phosphate coating; final finish as specified under Division 09. Doors shall be by Milcor.
 - 4. For Fire-Rated Ceiling: Doors for installation in fire-rated ceilings shall be UL rated for 1-1/2 hours in walls and shall carry the Warnock Hersey testing label for a 3 hour non-combustible floor/ceiling system. Panel shall contain 2 inch of insulation in sandwich type construction and shall have continuous piano hinge. Doors shall have automatic closure with self-latching lock with operating ring. Frames shall have anchor straps and mounting holes. Units shall be prime coated. Doors shall be Milcor Series 3218.
- C. Manufacturers: Panels shall be as manufactured by Milcor. Panels by Bilco or Karp Associates, meeting the above specifications will be considered for approval.

2.6 ELECTRIC MOTORS AND DRIVES

- A. Electric motors will be provided with equipment, apparatus and appliances specified in Divisions 23 and 26.
- B. Motors shall conform to following description unless otherwise noted or required:
 - 1. Motors smaller than 1/2 horsepower shall be single phase 60 Hertz; larger motors shall be 3 phase, 60 Hertz. Motors shall be wound for voltages, horsepower and starting method indicated in Equipment Data Schedule. Motors shall have service factor not less than 1.15. Motors furnished with packaged equipment such as air compressors, condensate pumps, deaerators, boilers, sump pumps, and similar packaged units shall be sized to avoid operation in the motor service factor. Motors shall have a nameplate indicating horsepower, voltage, phase, cycles, rpm, full load amps, locked rotor amps, frame size, model number, service factor, power factor and efficiency.
 - 2. Motors shall be equipped with ball or roller bearings; and where conditions of service require, suitable end-thrust bearings shall be incorporated in bearing design. Bearings shall be constructed to prevent lubricant leakage into motor under normal or excess lubrication. Permanently lubricated bearings will not be acceptable except for fractional horsepower or hermetically sealed units. Ball or roller bearings shall be equipped with Alemite or Zerk grease and relief fittings. Lubrication instructions shall be furnished with motors.
 - 3. Motor enclosures shall be selected for operating conditions encountered. Open dripproof frames are acceptable for indoor and protected applications and in locations free of dust and moisture. Motors shall be designed for continuous operation in a 104 deg. F. environment and shall be designed for temperature rise in accordance with NEMA MG1 limits for applicable insulation class, service factor and motor enclosure type. Motors larger than 25 horsepower shall have lifting lugs. Totally enclosed or encapsulated motors shall be used outdoors and in locations of adverse, non-explosive atmospheres. Explosionproof motors shall be furnished for installation in hazardous locations. Motors shall be designed for hazard encountered and bear UL labels listing class of service for which motors are protected. Motors shall have terminal boxes of adequate size to accommodate required conduit, wire and terminations. Terminal box shall have lugs sized in accordance with NFPA 70 and shall be threaded for conduit. Fractional horsepower motors shall be provided with threaded wiring connection in end frame.
 - 4. The performance characteristics of all motors shall meet operating requirements. For general application, such as constant speed drives including centrifugal pumps, etc., where requirements do not call for high starting torque, normal torque, low starting current motors shall be provided. Motors 50 horsepower and larger shall be NEMA Design B with a maximum locked rotor kVA per horsepower of 6.29 with code letter G nameplate. Three phase motors, 40 horsepower and smaller, where available with specified equipment, shall be energy-efficient motors. All motors used with variable frequency drives shall be energy-efficient motors. Manufacturer of motors used with variable speed drives shall verify motor compatibility with the specified variable frequency drive and shall certify that the use of the motor with the drive will not affect the motor warranty. These motors shall be for inverter duty and shall comply with NEMA MG1-1993, Part 31. Motor insulation shall meet 1600 volt peak with a rise time of 0.1 microsecond.
 - 5. All motors with VFDs shall have shaft grounding ring kits:
 - a. Manufacturer: Aegis, Model LSGR
 - b. Type: Maintenance free shaft grounding ring kits to protect motors and attached equipment from damaging shaft electrical currents at all motor speeds.
 - c. Furnished and factory installed by the equipment supplier.
 - 6. Class B insulation shall be provided as minimum standard for motors. See above for motors used with inverters (variable speed drives).
- C. Separately furnished motors shall be product of one manufacturer and shall conform to latest edition of motor standards as published by NEMA. Motors shall be shipped in manufacturer's

container properly identified. Stored motors shall be protected from weather and moisture by maintaining factory covers and suitable weatherproof covering.

- D. Manufacturer: Motors shall be as manufactured by Baldor. Motors by Magna-Tek, Lincoln, Reliance or Toshiba, meeting the above specifications will be considered for approval.
- E. Motor Drives: Drives for motors single horsepower and larger shall have no less than two (2) belts and be sized for minimum of 150 percent of motor horsepower. Drives shall be provided with guard covering belts, sheaves and shaft. Sheaves and Belts shall be replaced, if necessary, at Contractor's cost, to achieve specified or scheduled airflow rates.
- F. Installation: Motors shall be installed in accordance with manufacturer's instructions and as follows:
 - 1. Ensure motor shaft alignment to ± 3 mils.
 - 2. Check line voltage and phase with nameplate.
 - 3. Verify installation of grease fittings.

2.7 PAINT, GENERAL

- A. Material Compatibility:
 - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.
- B. Colors: Color of finish paints will be selected from manufacture's standard colors. Where red primers are specified, gray or white primers can be used on items to be finished with white, yellow or other lighter finish colors provided they meet the red primers specifications.
- C. Manufacturers: Paints shall be as manufactured by Devoe. Paint by Glidden, Sherwin-Williams (S-W), PPG Industries (Pittsburgh), or Benjamin Moore (Moore), meeting the above specifications will be considered for approval.

2.8 MAGNETIC MOTOR STARTER

- A. Starters specified to be furnished with equipment in Division 23 shall be as follows.
- B. Type of Starters: Type as called for in Equipment Data Schedule. Multi-speed motor starters shall be of proper type suitable for motor winding, i.e., single winding consequent pole or separate windings, and shall be complete with adjustable 0-90 second time delay when switching to low speed. Autotransformer and wye-delta starters shall be of the closed-transition type and shall incorporate features specified for full voltage starters. Refer to motor manufacturer's wiring diagram prior to ordering starters. Starters shall be combination type with fused disconnect switches. Reference Variable Frequency Drive (VFD) article for motors indicated to have a VFD.
- C. Auxiliary Contacts: Magnetic motor starters shall be provided with auxiliary contacts required for operation of any momentary closing starting device. Additional auxiliary contacts or relays for electrical interlock and automatic controls shall be furnished and installed to achieve interlocking, control and automation requirements.
- D. Overload and Reset:
 - 1. General (Thermal Overload Relays): Each phase of motor shall have a NEMA Class 20 thermal overload heater element to prevent heat damage to motor windings from overloads or excessive current. Motor starters shall have manual overload reset pushbutton unless otherwise indicated.
 - 2. Overloads shall be furnished and installed in field by Contractor except for factory prewired starters or control panels.

3. Overloads shall be properly sized by considering duty cycle, type starting, ambient temperature of motor and starter, and use of any power factor correction capacitors.
 4. Overloads shall be sized for 115 percent or 125 percent of full load current rating depending upon the motor's service factor and temperature rise as defined by NEC for continuous duty motors. Increase heater element rating to maximum allowed by code if problems such as motor shutdown occur during normal running or starting conditions. Overload relays shall be based on the motor's full load current (FLA) listed on its nameplate.
- E. Control Power Transformer (120 Volt): Starters serving motors that operate on voltages other than 120 volts shall be provided with factory furnished control transformers with 120 volt grounded secondary. Transformer primary coil shall be powered from load side of starter disconnect switch and be de-energized when switch is open. Transformer shall have two (2) fuses to protect control transformer's primary side. Control transformer 120 volt secondary shall have fuse in one lead to protect control circuit. Other lead shall be grounded and wired to motor overload contacts, not to the stop/start switch control contacts.
- F. Enclosures: Provide proper NEMA type enclosure for indoor, outdoor or hazardous area applications.
- G. Products of Single Manufacturer: Motor starters shall be the products of single manufacturer for convenience of Owner in stocking spare parts except for starters factory prewired on equipment.
- H. Manufacturer: Motor starters shall be by Allen-Bradley. Motor starters by Square-D, Siemens, General Electric, or Eaton Corp. meeting the above specifications will be considered for approval.

PART 3 - EXECUTION

3.1 SLEEVES AND OPENINGS

- A. General:
1. Where ductwork, piping or conduit passes through a wall or floor or floor/ceiling assembly, the penetration shall be constructed to minimize noise passage through the penetration and to maintain fire ratings where applicable. For ductwork, penetration opening shall be blocked or framed; for piping a sleeve shall be provided. The blocking, framing or sleeve shall provide an annular space on all sides of 1/2 inch to 3/4 inches. The duct, pipe or conduit shall be centered in the penetration opening. The annular space shall be packed with mineral wool or glass fiber to fill all voids. Non-hardening fire rated sealant shall be used around duct, pipe or conduit on both sides of the penetration to form an airtight and fire rated seal (where applicable). For fluid piping, the penetration shall be sealed after the pipe is under full load of the fluid in order to ensure the piping remains centered in the penetration. If necessary, adjustment to the hanger system shall be made after the pipe is loaded to maintain centering.
 2. No sleeves are permitted through concrete structural members unless indicated on Structural Drawings or approved by the Architect/Engineer.
 3. Clean surfaces in area of penetration of loose particles and dust.
 4. Sealant shall be finished flush with adjacent surfaces. See Paragraph B. below for exterior walls. See PART 2 of this specification section for approved firestop materials.
 5. Sleeves provided for future work shall be completely closed with firestop material.
- B. Exterior and Foundation Walls:
1. Piping penetrating walls shall pass through Schedule 40 galvanized or epoxy coated steel pipe sleeves with welded steel water stop. Anchor sleeve in wall and cut flush with both sides of wall. Burrs and sharp edges shall be filed smooth. Sleeve diameter shall allow annular space for seal material. Link seal "Century-Line" sleeves of thermoplastic construction may be used where service conditions do not exceed the limits of the sleeve specification.

2. Close annular space between sleeve and piping with interlocking synthetic rubber links except where fiberglass or plastic pipe is used. Where fiberglass or plastic pipe penetrates foundation walls, provide a heat shrink end seal over sleeve and pipe at outside edge of sleeve. See PART 2 of the specification system for interlocking link type seals.
 3. Ducts passing through exterior walls shall be provided with 1/4 inch thick angle frames. Fill space between duct and wall opening with firestop material. Secure angles to interior and exterior wall surface with through bolts. Exterior angle frame shall be set in mastic and silicon caulked to duct and exterior wall.
 4. All items routed through sleeves shall be sealed watertight.
- C. Interior Walls and Partitions:
1. Masonry or Concrete: Piping penetrating masonry or concrete walls shall pass through Schedule 40 black steel pipe sleeves. Sleeves shall be cut flush with both sides of wall and burrs or sharp edges filed smooth.
 2. Gypsum Board: Piping passing through gypsum board partitions shall pass through sleeves. Sleeves shall be Schedule 40 black steel pipe, or 20 gauge galvanized sheet steel at Contractor's option. Anchor sleeves to wall or partition and cut flush with both sides of wall and file burrs or sharp edges smooth.
 3. Duct Penetration Masonry or Gypsum Board: Ducts through interior walls and partitions shall be reinforced on both sides of wall with angle iron or galvanized sheet steel frames. Opening between ductwork and wall opening shall be filled with firestop material. Fire dampers shall be installed in accordance with UL and NFPA requirements where firewalls are involved. Steel shall be galvanized or painted.
- D. Floors:
1. Floor Sleeves: Sleeves shall be Schedule 40 black steel pipe extending 1 inch above floor to serve as water stop. Fill space between pipe and sleeve with firestop material. Unused sleeves shall be sealed with firestop material. Finished installation shall be watertight and maintain fire rating of floor.
 2. Fire-Rated Chases: Sleeves in floors of totally enclosed fire-rated chases or shafts do not require sealing.
 3. Duct Slots: Ducts through floors shall pass through framed openings and be provided with angle iron frames. Frames shall be fastened to floor and be sealed with silicon caulking to form watertight seal. Fill space between duct and angle frame with firestop material. Ducts provided with fire dampers shall be installed in accordance with UL requirements complete with floor sleeve in accordance with SMACNA fire, smoke and radiation damper installation guide for HVAC systems.
- E. Firestopping Systems:
1. Engage an experienced installer who is certified, licensed or otherwise qualified by the firestopping manufacturer as having the necessary experience, staff and training to install manufacturer's products in accordance with specified requirements. A manufacturer's willingness to sell its firestopping products to the Contractor or to an installer engaged by the Contractor does not in itself confer qualification on the buyer.
 2. Firestop system installation must meet requirements of ASTM E-814, UL 1479 or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
 3. Proposed firestop materials and methods shall conform to applicable governing codes having local jurisdiction.
 4. Firestop systems do not re-establish the structural integrity of load bearing partitions/assemblies or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.

3.2 ACOUSTICAL SEALS FOR PENETRATIONS OF ACOUSTICALLY SENSITIVE AREAS

- A. Penetrations by mechanical ductwork and piping through walls, floors or structural members of acoustically sensitive space shall be effectively sealed to limit noise transmissions and sound leaks.
- B. Materials, methods and techniques used to achieve effective acoustic seals at penetrations are described below and shown in the drawings.
- C. Framed opening for penetrations shall be sleeved when possible. Opening sizes should be large enough, but not so large as to allow more than 1 inch clearance on all sides of the penetrating item. Coordination with the General Contractor for sleeves and openings in walls and floors shall be the responsibility of this Contractor.
- D. Prior to implementation of sealing procedures, Contractor shall inspect the penetrations for proper clearances. If insufficient clearance exists, the Contractor will be responsible for achieving the specified clearance. If excessive clearance exists, more than 4 inches, the following shall be implemented: Attach two (2) layers of 5/8 inch gypsum board to each side of the wall which is cut around the penetrating element. One inch or less clearance should exist between the gypsum board and the pipe or duct. Fill the gap between the gypsum board layers with lightweight glass fiber batt or blown-in mineral fiber insulation. Seal the edges between the gypsum board and the penetrating element with a silicone-base, non-hardening and water and shrink resistant acoustical sealant.
- E. Once proper clearances have been established, Contractor shall implement the following:
 - 1. Gaps wider than 1 inch, but less than 4 inches, shall be filled with lightweight glass fiber insulation stuffed tightly in the gap to within 1 inch of the wall thickness on either side. Fill the remaining gap with continuous beads of acoustical sealant.
 - 2. Gaps of 1 inch or less shall receive mineral fiber insulation along the entire perimeter of the penetration. Stuff the mineral fiber insulation into the gap about 1 inch back from the wall surface. Fill the remaining gap with acoustical sealant.
- F. Where pipe, etc., pass through a given wall or floor at a specific location or area in sufficient numbers so as to make individual packing and sealing procedures impossible, the penetrating elements shall be enclosed in mechanical shafts with rated shaft wall construction or sealed as a group in the following manner:
 - 1. Frame the opening in the wall or floor so that the clearance around the penetrating elements is minimized, viewing the group of elements as a single element. Where this is not possible, attach two (2) layers of 5/8 inch gypsum board to each side of the wall and cut around the penetrating elements. If possible, cut the gypsum board around each penetration individually.
 - 2. Stuff lightweight glass fiber insulation completely into the gaps between and around the penetrating elements so view through to the opposite space is completely obscured. Caulk gaps between gypsum board and penetrating elements with acoustical sealant.
- G. When a penetrating element passing through a wall or floor is externally insulated, the insulation shall be interrupted as it passes through the penetration.

3.3 LINTELS

- A. Provide lintels as required for support of building construction above pipes, boxes panels and ducts where openings are cut in existing or already completed wall.
- B. Lintels shall be structural steel angles, channels or tees of proper size and sections for supported load.

3.4 ROOF OPENINGS AND CURBS

- A. Roof Openings:
 - 1. Provide sleeves for pipe openings in roof.

2. Framed openings in roof shall be provided in accordance with exact dimensions and locations of each required opening.

B. Roof Curbs:

1. Curbs shall be constructed in accordance with details and dimensions applicable to each curb unless prefabricated type curbs are specified.
2. Prefabricated roof curbs shall be of standard or sound attenuating type as specified in Section 235000.

C. Flashing and Counterflashing:

1. Flashing around roof curbs shall be provided as specified under Division 07. Provide counterflashings of 16 ounce CRC or galvanized iron except where counterflashing is component part of equipment such as roof exhausters. All flashing shall be in conformance with roof manufacturer's standard details as necessary to preserve roof warranty.
2. Openings for conduit and pipe sizes 12 inch or smaller passing through roof shall be made watertight by means of RPS, Caddy/Erco, or The Pate Company. Curbs shall be complete with acrylic coated ABS rib-reinforced plastic curb cover with prepunched mounting holes and equipped with EPDM protective rubber caps with stainless steel clamps.
3. Provide flashing for plumbing stacks consisting of prefabricated flashing ring extended 4 inch beyond stack and below roofing.

3.5 CONCRETE WORK

A. Housekeeping Pads for Equipment:

1. Provide housekeeping pads for floor-mounted equipment specified under Division 23 and where indicated on drawings.
2. Housekeeping pads shall be adequately reinforced for final equipment selections and according to seismic codes as specified in Section 232400.
3. Housekeeping pad thickness and size shall be adequate for final equipment selection for proper embedment of equipment and/or vibration isolation/seismic restraint anchors. Refer to written vibration isolation/seismic restraint instructions. Where requirements differ, housekeeping pad shall be designed to the most stringent requirements.
4. Housekeeping pads shall be 4 inch high or higher if noted on drawings.
5. Housekeeping pads shall be reinforced with 6 inch x 6 inch – W2.9xW2.9 flat welded wire fabric panels, lap separate panels 6 inch minimum. Rolled welded wire fabric will not be permitted.
6. Sides of housekeeping pads shall be formed neat, straight and plumb.
7. Coordinate pad requirements prior to framing and pouring of housekeeping pad. Provide 3/4 inch chamfer on all exposed edges.
8. Prepare substrate by roughening structural floor slab or applying bonding agent to structural floor slab prior to pouring of housekeeping pad.
9. Install 3/4 inch diameter undercut or adhesive anchors to connect housekeeping pad to structural floor slab. Anchors shall have a minimum of 2 inch embedment into structural floor slab and housekeeping pad. Unless otherwise indicated, anchors shall be installed with a maximum distance of 18 inches from edge of pad, 24 inches on center.
10. Concrete shall be 4,000 psi, small aggregate, 28 day compressive strength.
11. Cure concrete according to ACI 308 by one or a combination of the following methods:
 - a. Keep concrete surfaces continuously moist for not less than 7 days by moisture curing with water, fog or an adsorptive, water saturated cover, or by use of a moisture-retaining cover.
 - b. Apply a curing compound.
12. Concrete shall not be loaded until minimum 28 day compressive stress has been attained.

13. Any corrections to housekeeping pad required due to lack of coordination shall be made at Contractor's expense.
14. Vibration isolation, seismic restraints and associated anchorage are provided in Section 232400.

B. Concrete Inertia Bases:

1. Isolated concrete inertia bases will be required as specified under Section 232400.
2. Concrete inertia blocks shall be installed above housekeeping pads. Pads shall be reinforced as called for under "Housekeeping Pads for Equipment" in this Section and shall be restrained to withstand seismic conditions as specified in Section 232400.

3.6 ACCESS TO EQUIPMENT

A. Accessibility:

1. Control devices, specialties, valves, and removable panels on equipment shall be located to provide easy access for inspection and maintenance including removal of interior components.
2. Work installed without regard to accessibility of devices shall be relocated, offset or rerouted without cost to Owner.

B. Access Panels:

1. Furnish access panels for installation under Division 06 where devices are concealed in walls or above non-removable ceilings.
2. Panels shall be at least 4 inch larger in all dimensions than devices to be accessed and be not less than 8 inch square for wall panels and not less than 12 inch square for ceiling panels. Larger panels shall be provided where opening is to allow personnel entry. No panel for personnel entry shall be smaller than 24 inch x 24 inch.
3. See PART 2 for access panel construction.

3.7 MECHANICAL COORDINATION FOR ELECTRICAL WORK

A. The Division 23 Contractor shall provide all labor and material for the following requirements:

1. Provide complete and accurate wiring diagrams for equipment requiring electrical power wiring.
2. Provide adjustable motor bases and bolts and nuts required for installation of base and motor.
3. Align and adjust mechanical couplings associated with direct-driven motorized equipment. Adjust and align drive and belt tension on belt-driven equipment.
4. Field lubricate motors prior to operation and maintain lubrication prior to acceptance of equipment by Owner.
5. Provide motor terminal connection diagram as prepared by motor manufacturers.
6. Install, mount and wire all electrical equipment and devices shipped loose for field installation that is furnished with mechanical equipment provided under this contract.

3.8 EXCAVATION AND BACKFILL

- A. Provide excavation and backfill required for work under Division 23. No excavation or backfill shall be within drip line of trees not shown to be removed on Architectural Drawings. No trees shall be removed without prior approval of Architect. Provide protection for trees within 15 ft. of utility excavation.**
- B. Trenching: Trench width shall be no more than required for shoring, bracing and performance of work. Necessary shoring and bracing shall be installed to ensure worker safety and proper installation of work. Depth shall not exceed that required to achieve specified depth of cover. Overdig will be permitted for bedding material only. Trenches shall be open cut from surface.**
- C. Bedding: Work shall be properly bedded on granular bedding. Granular bedding shall be laid on undisturbed soil. Coated, plastic, FRP, factory-insulated pipe, and copper piping shall have**

4 inch sand bed. Cast iron, ductile iron piping laid on filled ground shall have 6 inch bed of limestone screenings with copious quantities of limestone dust. Cast iron, ductile iron piping shall have trench shaped to fit contour of bottom one quarter of pipe circumference with due allowance for bells to prevent unevenness along invert of pipe. Excavate to point 3 inch below installed bottom elevation of piping and provide bedding as called for above if rock is encountered. Encase in 3000 pound concrete where pipe is subjected to motor traffic and similar loading.

- D. Backfill: Backfill shall not begin until installation has been leak tested. Consult with Authority Having Jurisdiction and with Architect/Engineer prior to backfilling.
 - 1. Initial backfill shall be of same material used for bedding to minimum distance of 6 inch above top of installed work, except as follows:
 - a. For drain tile, see drawings.
 - b. Use 3/4 inch minus crusher run limestone with copious quantities of limestone dust for cast iron, ductile iron piping bedded with virgin soil.
 - 2. Final Backfill:
 - a. Within Building: Granular material, 3/4 inch minus crusher run limestone with copious quantity of limestone dust.
 - b. Outside Building Under Paved Areas: Granular material, 3/4 inch minus crusher run limestone with copious quantity of limestone dust to bottom of pavement.
 - c. Outside Building and Not Under Paved Areas: Clay soil free of vegetable matter and foreign material. Use clay soil to point 6 inch below finished grade and use clean black topsoil to finished grade where in planted areas. Site materials free of organic and foreign materials will be acceptable in lieu of clay soil called for above.
- E. Placement: Place material in lifts of 6 inch maximum compacted thickness densified to minimum relative density of 95 percent under structures and paved areas and of 90 percent under unpaved areas as determined by ASTM D-1557. Do not place backfill until excavations have been cleared of water, debris and loose or soft soil.
- F. Protection: Provide required barricades, fencing, bracing, piling, signs, lights and pumping as necessary for protection of workers and general public. Work shall comply with applicable safety codes and local regulations.
- G. Excess Material: Excess earth and other material resulting from excavation shall be removed from site or may be piled at location designated and approved by Owner and Architect/Engineer. Debris, rock and trash shall not be allowed to accumulate and shall be removed from site. Streets, roadways and private property shall be kept in clean condition.
- H. Rock Excavation: See Division 01.
- I. Restoration of Existing Conditions:
 - 1. Backfill to height of rough grade when excavation is within area of finished site work. Final surfacing will be under Division 02.
 - 2. Final surface and adjacent disturbed areas shall be restored to match original condition by sodding, seeding, asphalt paving or concrete as required. Work shall conform to applicable sections of specifications.
 - 3. Restoration of surface conditions shall meet requirements of Authorities Having Jurisdiction when excavation is on public property.

3.9 PAINTING

- A. Work Included:
 - 1. Uninsulated piping, ductwork and steel supports, except materials fabricated of galvanized steel, copper or aluminum exterior of building shall be painted.
 - 2. Supporting steel and hangers for piping, equipment and ductwork, except made of galvanized steel, shall be shop coated with rustproof primer or shall be field painted

except where installed above ceilings or where concealed in shafts. Concealed supports and hangers do not require painting. Hangers in mechanical spaces shall receive field coat over primer.

3. Steel components for equipment supports shall be shop coated with rustproof primer and field painted.
4. Uninsulated ferrous piping and ferrous metal in mechanical spaces shall be painted. Do not paint sprinkler heads.
5. Piping welds shall be wire brushed and painted prior to application of insulation.
6. Bands on Piping in Mechanical Rooms: Painted bands shall be minimum 12 inch in length around pipe and be located to serve as background for piping identification stencils as called for in Section 231900.
7. Manufacturer's finished products as specified below.

B. Work Not Included:

1. Piping, ductwork, conduit and outlet boxes exposed in finished rooms or corridors shall be painted under Division 09. Work above ceiling shall not be painted.
2. Ductwork in mechanical rooms and duct shafts will not be painted.
3. Exposed grilles, diffusers, unit cabinets and panels specified to be finished with prime coat at factory shall be field painted under Division 09.

C. Manufacturer's Finished Products:

1. Manufacturer's finished products, such as water chillers, boilers, pumps, fans, air handling units, control panels, and similar items shall have factory standard finish.
2. Touch up minor damages or scratches due to shipment, installation or exposure to weather on equipment with baked or sprayed enamel or equivalent finish. Prime coated equipment shall be cleaned but will not require touch up. Entire piece of equipment shall be repainted to match factory finish where large areas of finish are damaged.

D. Painting Specifications:

1. Painting work shall be performed by required trades in neat and workmanlike manner. Painting materials shall be of best quality and suitable for service intended. Finish paints shall present glossy finish.
2. Surfaces to be painted shall be free of rust, scale, peeling, blistering, grease, oil, or deteriorating film prior to application of primer.
3. Applicable parts of Division 09 shall govern work under this section.

END OF SECTION 230500

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INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 230600 – PIPING

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL PIPING REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		1
2.1	FITTING MATERIALS	1
2.2	PIPING MATERIALS	2
2.3	MECHANICAL COUPLINGS	2
2.4	COPPER OR BRONZE PRESSURE-SEAL FITTINGS	3
2.5	VALVES	3
2.6	PIPING SPECIALTIES	5
2.7	REFRIGERATION SPECIALTIES AND VALVES	8
2.8	NEW GAS SERVICE	9
2.9	UTILITY SERVICES	9
2.10	GAUGES AND THERMOMETERS	9
2.11	FASTENER SYSTEMS	10
PART 3 - EXECUTION		10
3.1	PIPING INSTALLATION	10
3.2	SUPPORTS AND HANGERS	12
3.3	PIPE TESTING	13
3.4	CLEANING OF PIPING	14
3.5	GENERAL	15

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SECTION 230600 - PIPING

PART 1 - GENERAL

1.1 REFERENCES

- A. Sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to work under this specification section.

1.2 GENERAL PIPING REQUIREMENTS

- A. Drawings and specifications are as complete as practical. Contractor shall furnish and install necessary components, such as cleanouts, fittings, vents, drains, valves, controls, escutcheons, and access panels for proper functioning and finished appearance of equipment and systems in accordance with recognized standards of practice. Piping indicated on drawings is diagrammatic; Contractor shall offset piping within a radius of 10 ft. from indicated location as required to coordinate with field conditions as directed by Engineer at no extra cost.

1.3 SCOPE OF WORK

- A. This section covers providing of pipe, valves, fittings and related devices and materials required under all sections of Division 23 including heating and air conditioning, plumbing and fire protection. Install piping wells, flow switches, automatic valves, Annubars and other control items required to be mounted in piping. Coordinate all such work with work specified under Section 239500 - CONTROLS AND INSTRUMENTATION.

1.4 DESCRIPTION OF SYSTEMS

- A. Major piping systems for this project consist of the following:
 - 1. Chilled Water
 - 2. Heating Water
 - 3. Cooling Coil Drains
 - 4. Heat Recovery (Glycol)
 - 5. System Drains and Vents
 - 6. Natural Gas
 - 7. Chemical Feed Lines

1.5 SUBSTITUTIONS

- A. No substitutions will be allowed except as specified under Section 230100 - BASIC MECHANICAL REQUIREMENTS.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 230100 - BASIC MECHANICAL REQUIREMENTS.
- B. LEED Submittal:
 - 1. Product Data for Credit EQ 4.1: For adhesives, sealants and sealant primers, including printed statement of VOC content and chemical components.

PART 2 - PRODUCTS

2.1 FITTING MATERIALS

- A. Fittings for steel pipe 2-1/2 inch and smaller shall be 150 pound standard malleable iron screwed fittings.
- B. Fittings for steel pipe 3 inch and larger shall be long radius welding fittings of same wall thickness and materials as pipe.

- C. Fittings for copper pipe shall be wrought copper.
- D. Fittings shall be manufactured by Grinnell, Crane or Mueller Brass. Fittings in PVC pipe shall be of same manufacturer as pipe.

2.2 PIPING MATERIALS

- A. Pipe Material: Unless otherwise indicated, all above grade steel piping shall be ASTM A53, Grade B. Copper pipe shall be ASTM B88.
- B. Heating Hot Water: Schedule 40 black steel or Type L hard temper copper. Contractor must ensure insulated dielectric unions are used between dissimilar materials.
- C. Chilled Water and Process Chilled Water: Schedule 40 black steel or Type L hard temper copper. Contractor must ensure insulated dielectric unions are installed between dissimilar materials.
- D. Cooling Coil Drains:
 - 1. Central Units: Type M hard temper copper.
 - 2. Fan Coil Units: Type M hard temper copper.
 - 3. Condensate drain lines shall be the same size as the connection size to the equipment unless noted otherwise on drawings.
- E. Refrigerant: Type ACR hard drawn copper refrigerant tubing shall be ASTM B-280.
- F. Natural Gas: Schedule 40 black steel. 3 inch and larger shall be welded; 2-1/2 inch and smaller may be screwed with local utility company's approval. Gas piping installed in mechanical room plenums or in ceiling plenums or where concealed in inaccessible plenums and chases shall have welded joints and fittings and shall not have valves installed within the spaces.
- G. Makeup Water: Type L hard temper copper.
- H. Relief Vents: Relief valves and rupture discs, pressure regulator vents and gas pressure switch vents shall be piped full size of valve outlet to atmosphere outside building. For multiple valve installations common discharge pipe shall have cross-sectional area equal to sum of outlet areas of connected valves. See PART 3 for termination of vent pipes.
 - 1. Water: Schedule 40 black steel.
 - 2. Natural Gas: Schedule 40 black steel.
 - 3. Refrigerant: Schedule 40 black steel.
- I. Heat Recovery (Glycol): Schedule 40 black steel
- J. Chemical Feed Lines: Type L hard temper copper.

2.3 MECHANICAL COUPLINGS

- A. General:
 - 1. At Contractor's option mechanical pipe couplings and fittings may be used on steel or cast iron piping in lieu of flanged, welded, screwed, or union connections for services listed below:
 - a. Chilled water
 - b. Heating hot water below 230 deg. F.
 - 2. Couplings and fittings shall be by Victaulic as specified. Fittings by Anvil, Grinnell or Stockham meeting these specifications will be acceptable.
- B. Couplings:
 - 1. Style 07, fabricated of ductile iron casting meeting ASTM-A536. Couplings shall be suitable for working pressures up to 700 psi through size 6 inch, 400 psi for 8 inch through 12 inch and 250 psi for larger sizes.

2. Gasket shall be Grade EPDM, Type E.
 3. Bolts of oval neck track head type with hexagonal nuts in accordance with ASTM-A-183.
- C. Fittings shall be Victaulic full flow type fabricated of malleable or ductile iron. Where Victaulic fitting pattern is not available, standard seamless welding fittings may be used.
- D. Installation:
1. Before assembly of couplings, lightly coat pipe ends and outside of gaskets with Victaulic lubricant to facilitate installation.
 2. Pipe shall be roll-grooved in accordance with manufacturer's specifications and instructions.
 3. Manufacturer's field instructions shall be provided.

2.4 COPPER OR BRONZE PRESSURE-SEAL FITTINGS

- A. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- B. Housing: Copper.
- C. O-Rings and Pipe Stops: EPDM.
- D. Tools: Manufacturer's special tools.
- E. Minimum 200 psig working pressure rating at 250 deg. F.
- F. ASME B16.51.
- G. Pressure-Sealed Joints: Use manufacturers recommended tool and procedure. Leave insertion marks on pipe after assembly.
- H. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. NIBCO Inc.
 2. Viega

2.5 VALVES

- A. General:
1. Globe valves, check valves and hose end valves shall be of the manufacturers indicated or of equivalent performance, construction, temperature and pressure ratings as manufactured by Grinnell, Victaulic, Crane, Milwaukee Valve Co., Hammond Valve, or Nibco. Specialty valves, butterfly valves and ball valves shall be by manufacturers indicated in specific paragraphs. Architect/Engineer reserves the right to request and inspect samples of valves prior to construction for approval.
 2. Main OS&Y shutoff valves installed 10 ft. or more above floor or platform shall be provided with chain-operated hand wheels with operating chains down to 7 ft. level.
- B. Globe Valves for Hot Water and Chilled Water:
1. 2-1/2 Inch and Smaller: 150 psi SWP, 300 psi non-shock cold OWG, bronze, inside screw, rising stem, union bonnet, renewable and replaceable Teflon disc, screwed ends, malleable iron handle.
 2. 3 Inch and Larger: Class 125, 200 psi non-shock cold OWG, iron body, bronze mounted, OS&Y, regrind-renew bronze disc and seat ring, flanged ends.
- C. Hose End Valve: Bronze ball valve with chrome-plated ball, blowoutproof stem design, 3/4 inch NPT hose-end connection with cap and chain; valve shall be 3/4 inch by Milwaukee Valve Co., Hammond, Apollo or Nibco. Valves shall have Teflon seats and seals and be rated at 600 psig WOG.
- D. Ball Valves: 150 psi SWP, 600 psi non-shock cold OWG, bronze (ASTM B-584, B-62, B-61) ball valve, screwed ends, twin Teflon seats, bronze body and stainless steel ball and stem.

Valves shall have 1-1/4 inch minimum extended stem to allow for insulation. Valves bodies shall be of two-piece construction. Valves shall be full port Apollo 77-140 series or equivalent by Milwaukee Valve Co., Hammond, Nibco, Apollo or Watts. Ball valves shall be used for shutoff service in sizes 2 inch and smaller.

NOTES: Memory stops available for balancing service.

E. Butterfly Valves:

1. Butterfly valves may be used in lieu of globe and balancing valves for sizes 2 inch and larger as specified below. Valves adjacent to flanges, which may be removed for service shall have full-lugged ductile iron bodies (ASTM A-536).
 - a. General Service Valves: For chilled water, condensing water and low temperature hot water construction shall be as follows:
 - 1) 150 psi working pressure with bubbletight shutoff without need for downstream flange
 - 2) Body: Cast iron/ductile iron
 - 3) Disc: Aluminum bronze
 - 4) Stem: 416 stainless steel blowout restrained with lever handle or actuator removed
 - 5) Seat: EPDM
 - 6) Handle: Ductile iron/cast iron
 - 7) 2 inch extended neck for insulation
2. Valves without gear operator shall have removable handle with infinite 90 degree notch with 10 degree increment position lock. Valves 8 inch and larger shall have gear operator and memory stop. Valves shall have sufficient neck length to accommodate 2 inch of insulation. Gear-operated valves shall have a tamperproof padlock device.
3. General service valves shall be by Nibco, DeZurik, Victaulic, Milwaukee Valve Co., Hammond Valve, or steam service and high-pressure water service valves shall be high-performance valves by Flowseal, Milwaukee, Posi-Seal or Jamesbury. When piping system utilizes mechanical couplings, grooved end valves rated at 300 psig working pressure by the manufacturer of the coupling may be used. Valves shall be suitable for dead end bubbletight shutoff.

F. Pump Discharge Valves: Discharge valves at each pump shall be combination type shutoff, balancing and check valves. Check valve shall be spring loaded and of the silent type. Valves shall be by Bell & Gossett, Armstrong or Mueller or Taco. Valves shall be rated for a working pressure of 175 psi.

G. Balancing Cocks:

1. 1/2 Inch Through 2 Inch: DeZurick Figure 499, cast iron body, non-lubricated eccentric bronze plug, molded plastic seat suitable for water to 250 deg. F., bronze bearings, 175 psig non-shock WOG pressure rated. Valves shall have screwed end connections and memory stop. (At Contractor's option, circuit balancing or ball valve with memory stop may be used.)
2. 2-1/2 Inch Through 4 Inch: DeZurick Figure 499, cast iron body, nickel-plated, non-lubricated eccentric cast iron plug, molded plastic seat suitable for water to 250 deg. F., bronze bearings, 175 psig non-shock WOG pressure rated. Valves shall have flanged ends and memory stop.
3. 5 Inch and Larger: Use butterfly or globe valves.

H. Check Valves:

1. 2 Inch and Smaller: 125 psi SWP, 200 psi non-shock cold OWG, bronze, body and disc, screwed ends, swing check.
2. 2-1/2 Inch to 12 Inch: Class 125, 200 psi non-shock cold OWG, bronze trimmed, swing check, regrindable and renewable bronze disc and seat ring, bolted cover.

I. Gas Valves:

1. Distribution Pressure (1 psi or Higher): Semi-steel, screwed ends, stainless steel spring, lubricated plug, operating wrench, 175 psi OWG, ACF Fig. 1430, UL listed for natural gas.
2. Low Pressure (Below 1 psi):
 - a. 3 Inch and Smaller: Bronze, tee handle with check, chrome-plated ball, Teflon packing, screwed ends, 600 psi WOG, UL listed for natural gas, Nibco T-585-70-UL (1 inch and smaller) or Nibco T-580-70-UL (1-1/4 inch to 3 inch). Valves by Milwaukee Valve Co. or Hammond, meeting the above specifications will be considered for approval.
 - b. 4 Inch and Larger: 200 psi OWG, semi-steel, flanged ends, lubricated plug, operating wrench, Homestead Fig. 611 or 612.
3. Pressure Regulating Valve: Provide a Fisher gas pressure regulator to reduce gas pressure from 2 psi to 7 inch w.c. for kitchen use. Regulator shall have capacities as listed on drawings. Regulators similar to Fisher, having the capacities listed, will be reviewed for approval. Regulators shall be vented to exterior of building.
4. Gas Solenoid Valve: Provide an automatically operated gas solenoid valve in the gas supply piping to the kitchen. Valve shall be an Asco, normally closed two-way fuel gas service solenoid valve, UL listed and FM approved. Valve shall be line size.

J. Circuit Setter (Combination Flow Measuring and Balancing Device):

1. Furnish and install where required for proper system balancing, calibrated balance valves for 200 psi working pressure at 250 deg. F. Valves through size 2 inch shall be all bronze; larger valves shall have cast iron bodies. Valves shall be Bell & Gossett circuit setters. Balance valves through size 3 inch shall be provided with preformed polyurethane insulation. Larger valves shall be insulated as specified for valves in Section 232500 - MECHANICAL INSULATION. Each unit shall have a memory stop and an integral pointer to indicate degree of valve opening and shall have provisions for connecting a portable differential-pressure meter. Circuit setter shall have a maximum pressure drop of 5 ft. of water at the design flow rate. Circuit setters shall be screwed, flanged or grooved to match piping system. Similar devices by Armstrong, Watts, Tour and Anderson, Nexus Valve, or Nibco will be acceptable.
2. Provide one metering device to read flow through circuit setters. Also provide conversion chart.

K. Circuit Sensors: Furnish and install where required for proper system balancing, individually calibrated nickel-plated orifice inserts constructed for 150 psi working pressure at 250 deg. F. Metering orifices shall be Bell & Gossett Circuit Sensor with provisions for connection of a portable differential-pressure meter. Similar devices by Armstrong, Watts, Tour and Anderson, or Taco will be acceptable.

L. Annubars: See Section 239500 - CONTROLS AND INSTRUMENTATION for Annubars. Annubars shall be installed under this specification section.

2.6 PIPING SPECIALTIES

A. Strainers: General Services

1. Location: Strainers shall be provided upstream of all pumps, automatic control valves, pressure-reducing stations and steam traps. (NOTE: When pump is provided with suction diffuser, which has integral strainer, the independent strainer will not be required.)
2. Construction: Strainers shall be Y pattern type with 125 pound rating. Where indicated, basket type strainers shall be provided.
3. Body: Iron for steel and bronze for copper pipe.
4. Screens: Perforations of screens shall comply with the following:
 - a. Water: 0.057 inch to 1/8 inch diameter.

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Webster University
Cannon Design Project No. 004561.01**

5. Screen Material: Stainless steel.
 6. Ends: Sweat ends for copper pipe; screwed or 150 pound flanged for steel pipe.
 7. Contractor shall include full size blow-down valve with capped end, on each strainer.
 8. Manufacturers: Strainers shall be provided for type of service required by Armstrong, Mueller Steam Specialty Co., Sarco, Grinnell, Victaulic, Watts, or Keckley.
- B. Startup Strainers: Stainless steel mesh with 1/4 inch perforations with perimeter ring to match flange.
- C. Expansion Tanks:
1. Furnish and install expansion tanks as shown on the drawings.
 2. Expansion tanks shall be of the pressurized diaphragm type and shall be rated for 125 psi working pressure, 250 psi test pressure and 240 deg. F. maximum operating temperature. Tanks shall be Extrol as manufactured by American Tube & Controls or equivalent by Bell & Gossett.
 3. See drawings for size of tanks and piping details. Charge pressure will be indicated on shop drawings.
- D. Air Extractors: Install full-line size Bell & Gossett Rolairtrol rated at 125 psi or as noted on drawings. Unit shall be furnished without strainer. Similar extractors by Armstrong or Taco will be acceptable.
- E. Makeup Water Pressure-Reducing Valves: Valve shall be Bell & Gossett Model B7-12, 10 to 25 psi range. Similar valves by Watts will be acceptable.
- F. Relief Valves:
1. Location: Relief valves shall be provided in chilled water system. No shutoff valves shall be installed between the relief valve and the system or the item of equipment protected by the relief valves. Chilled water relief valve shall be located between the chiller and the chiller isolation valves to protect chiller. Hot water relief valve shall be installed in cold-water makeup pipe between the PRV and expansion tank inlet.
 2. Construction: All relief valves shall be ASME rated and shall be sized in accordance with requirements of ASME Unfired Pressure Vessel Code.
 3. Manufacturers: Relief valves shall be as manufactured by Bell & Gossett, Kunkle, Lonergan, or Watts.
- G. Expansion Joints and Expansion Compensators:
1. General: Provide expansion joints and expansion compensators where required to compensate for pipe expansion and at building expansion joints. Expansion joints shall be anchored and pipe shall be guided with factory-fabricated guides in accordance with manufacturer's recommendations for expansion joint installation and guide spacing.
 2. Expansion Joints (EJ-1):
 - a. Joints shall be sliding-sleeve type with flanged ends and shall be designed to permit addition of new packing while joint is in service under full-line pressure.
 - b. Sleeve shall be of polished seamless wrought steel with heavy plating of smooth nickel for corrosion resistance and a second plating of hard chromium for wear resistance.
 - c. Body and gland shall be of one-piece, welded construction with integral fixed gland ring providing internal and external guides. Internal guides shall be a close fitting cylindrical bearing surface located on inside of stuffing box. Joints shall be rated at 150 psi.
 - d. Packing rings shall be fitted with radial bosses of the prescribed number, each with a packing gun consisting of a stainless steel cylinder and bronze plunger, screw actuated, to accept semi-plastic molded plug type packing without removing old packing. Rams shall be replaceable assemblies with safety lock to prevent accidental disengagement.

- e. Packing guns shall be designed to prevent backflow of packing due to internal pressure and shall be of straight standard pattern. Rams shall include a safety check valve to ensure that packing will not blow out during repacking.
 - f. Alemite fittings shall be provided in the gland ring for lubrication of packing and sliding sleeve. Straight type fittings of double check type shall be furnished, attached radially to gland, each with a sealing cap.
 - g. Joints shall be delivered completely packed, ready for installation and each shall include six (6) extra plugs of packing, wrench-matching inserter, and one can of high super-heat mineral oil type lubricant.
 - h. Provide guides and anchors as required to provide a complete system in accordance with the "Standards of the Expansion Joint Manufacturer's Association Inc."
 - i. Manufacturer shall guarantee the expansion joint to be free of defects and performance for a period of five years from the date of acceptance of project by Owner.
 - j. Expansion joints shall be by Yarway, Advanced Thermal Systems, Inc., or ADSCO.
3. Expansion Joints (EJ-2):
- a. Joints shall be controlled flexing corrugated bellows, fabricated of Type 304 stainless steel and rated for 300 psi and up to 800 deg. F. operating temperature.
 - b. Expansion joints shall have external sheet metal covers to facilitate field application of insulation and shall have fixed flanges at both ends to facilitate replacement.
 - c. Provide guides and anchors as to provide a complete system in accordance with the "Standards of the Expansion Joint Manufacturer's Association Inc."
 - d. Joints shall have the required number of corrugations for each application.
 - e. Expansion joint shall be as manufactured by Flexonics, Global-Flex or ADSCO.
4. Expansion Compensators (EC):
- a. Compensators shall be rated at not less than 125 psi working pressure, shall have maximum compression stroke not less than 1-3/4 inch, and shall have extension stroke not less than 1/4 inch.
 - b. Bellows shall be two-ply, stainless steel for steel pipe and shall be 2-ply, bronze for copper pipe. Joints shall have an anti-torque device and internal guides extending full length of bellows travel.
 - c. Line pressure shall be external to bellows, and bellows shall be under tension during compression stroke (pipe expansion).
 - d. Compensators shall be Flexonics Model H for steel pipe and Flexonics Model HB for copper tubing or similar manufactured by Global-Flex.
 - e. Provide guides and anchors to provide a complete system in accordance with the "Standards of the Expansion Joint Manufacturer's Association Inc."
- H. Suction Diffusers:
- 1. Provide a suction diffuser at each base-mounted or vertical pump. Body shall fit pump suction flange and shall be rated for a working pressure of 175 psi.
 - 2. Units shall consist of angle type body with inlet vanes and combination diffuser/strainer orifice plate with 3/16 inch diameter openings for pump protection.
 - 3. Units installed in closed systems shall be equipped with a 16-mesh bronze disposable fine mesh startup strainer, which shall be removed after 30 days of operation. (NOTE: It shall be the responsibility of the Contractor to remove the fine strainer from each diffuser after the 30 day operating period.)
 - 4. Velocity through strainer-free area shall not exceed 2 fps and the pressure drop shall not exceed 1 psi at specified flow.
 - 5. Unit shall be provided with adjustable support foot to carry weight of suction piping.
 - 6. Type X, cast iron body, steel inlet vanes and steel orifice plate.

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Cannon Design Project No. 004561.01**

7. Manufacturer: Units shall be made by Bell & Gossett. Units by Armstrong, Taco or Victaulic meeting the above specifications will be considered for approval.

I. Flexible Pipe Connections:

1. Piping connections to vibration generating equipment shall be provided with flexible connectors.
2. Connectors shall be line size, fabricated of DuPont TFE-6 molded black Teflon bellows with Monel reinforcing rings. Control units shall have complete insulating grommets and entire unit shall have published dynamic pressure/temperature ratings with a 4:1 safety factor. Connectors shall be Resistoflex Model R-6904 or as required for the temperature and pressure of the system. At Contractor's option, Thermotech, Inc., Flex/Flo/R, or Global-Flex flexible connectors rated at 250 deg. F. and 150 psi with 300 psi test may be used.
3. Flexible connections indicated in refrigerant piping and in other systems with operating characteristics exceeding the limitations of the bellows type connectors shall be tin, bronze or stainless bellows hoses, with bronze or stainless steel braid covering and copper or other applicable tube end material, braze-welded into an integral unit. Metal hoses shall be Anaconda vibration eliminators with pressure limit compatible with system pressure and of manufacturer's standard length. Similar products manufactured by Flexonics or Global-Flex will be acceptable.

J. Heating Water and Chilled Water Differential Pressure Control Valve: Furnish and install a water differential pressure regulator of the external pilot type. Valve shall be self-operated and be of single seated packless construction, hycar diaphragm actuated. Regulator shall be a Spence Type C34N20 and shall open as required to regulate the pressure and flow as noted on plan. Valve shall provide 100 percent shutoff when closed.

1. There shall be no springs in the path of water and no stuffing boxes. All parts must be accessible without removing valve from line.
2. Body of main valve and external pilot shall be cast iron. Valve shall be rated for 125 psi. Valves 2-1/2 inch and larger shall be flanged.
3. Pilot valve shall be separate from the main valve and be connected to main valve with unions. Pilot shall be interchangeable with all sizes of main valves.

K. Flexible Metal Hose:

1. Furnish and install flexible hoses between equipment and piping and at building expansion joints.
2. Flexible hose shall be of necessary length to absorb misalignment and to provide sufficient deflection to allow for equipment movement due to isolator deflection. Hose shall be rated for pressure and temperature of service intended and shall be of 2-ply corrugated bellows type made of stainless steel with braiding similar to vibra-sorbers made by Flexonics or Global-Flex.

2.7 REFRIGERATION SPECIALTIES AND VALVES

A. Provide all equipment, piping, accessories, and refrigerant specialties specified and required to complete the system, for manufacturers requirements.

B. Valves:

1. Line Valves: Mueller Brass packed line valves, backseating solder-to-solder.
2. Solenoid Valves: Sporlan Valve Co. or Alco Valve Co.; normally closed, packless.
3. Thermostatic Expansion Valves: Sporlan Valve Co. or Alco Valve Co. external equalizer, external remote bulb, Alco W or equal power element charge.

C. Specialties:

1. Filter Driers: Filter driers shall be combination type with replaceable cores and shall be Sporlan Catch-All, Mueller Drymaster or Alco ADK. Filter driers shall be installed in accordance with manufacturer's recommendations.

2. Moisture and Liquid Indicators: Sporlan See-All, Mueller Vuemaster, or equal combination moisture and liquid indicator as manufactured by Alco Valve Co.
3. Flexible Connector: MetraFlex Model RAF flexible connector for all refrigerant-piping connections to equipment.

2.8 NEW GAS SERVICE

- A. Utility company shall install gas service line and main gas pressure regulator.
- B. Provide space for gas meter and provide secondary gas pressure regulators as noted on drawings

2.9 UTILITY SERVICES

- A. All utility services required for this project shall be obtained from present house piping systems. No new utility connections are required.

2.10 GAUGES AND THERMOMETERS

- A. Other than installed on factory-packaged equipment, pressure gauges and thermometers shall comply with the provisions of this paragraph. Gauges and thermometers shall be installed between 7 ft. at the highest and 5 ft. at the lowest above floor or platform. Where necessary provide armored capillary bulb and remote gauge. Pressure gauge tappings except on gauges with integral valves shall be provided with Weksler or equivalent brass bar stock needle valve, Model BBV4 rated for 600 psi WOG.
- B. Pressure Gauges:
 1. Construction:
 - a. Accuracy: Grade A, within 1/2 percent of scale range.
 - b. Movement: Stainless steel rotary gear design.
 - c. Material: Phenol case; white-coated iron dial.
 - d. Dial Size: 4-1/2 inch diameter.
 - e. Scale: Range of scale shall be selected with normal operating pressure at 1/2 or 2/3 position of the dial.
 2. Manufacturers: Gauges shall be by Trerice Series 450X or equivalent by Ashcroft, Palmer or Weksler and shall be complete with pulsation dampener.
 3. Locations Required:
 - a. At Pumps: Provide one hydronic indicator at each base-mounted or vertical pump; see paragraph entitled "Hydronic Indicator System".
 - b. At PRV Stations: Provide gauges at inlet, intermediate stage and low-pressure header.
 - c. At Heat Exchanging Equipment: Provide gauge tappings with 1/4 inch needle valves as specified above at the inlet and outlet of equipment only. At Contractor's option, "Pete's Plug" may be used where cocks only are required. No gauges need be provided unless specifically shown on drawings. Heat exchanging equipment shall include heat exchangers, converters and boilers. Terminal units, such as fan coil units, unit ventilators, reheat coils; need not be provided with gauge tappings.
 - d. Other locations as indicated on the drawings.
- C. Thermometers:
 1. Construction:
 - a. 9 inch die cast aluminum with metallic blue-black finish, adjustable angle.
 - b. Clear acrylic plastic window with cap.
 - c. Lens front red-appearing organic liquid filled tubing.
 - d. White background scale with black figures.
 - e. Brass Stem: Brass union connection fittings and socket.

2. Manufacturers: Thermometers shall be Terence BX 91403-1/2 with Fahrenheit scale or similar by Weiss, Palmer or Weksler.
3. Locations Required:
 - a. Water Heating Equipment: Water heating equipment, such as hot water converter, storage heater, instantaneous heaters, shall be provided with thermometer at outlet but with thermometer well only at inlet.
 - b. Air Handling Unit Coils: Provide thermometers at inlet and outlet of chilled and hot water coils. Also, provide matching thermometer wells.
 - c. Air Handling Unit Plenums: Provide 1 inch pipe test opening with screw-on cap at outside air, discharge air, and mixed air plenums.
 - d. Automatic Control Systems: Thermometers required for the proper operation and adjustment of automatic controls shall be provided under Section 239500 - CONTROLS AND INSTRUMENTATION work.
 - e. Heat Exchangers: At the water inlet and outlet.

2.11 FASTENER SYSTEMS

- A. Anchors: Insert wedge type zinc-coated steel mechanical expansion anchors or adhesive anchors, for use in concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Manufacturers:
 - a. B-Line Systems, Inc.; a Division of Cooper Industries
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/RedHead
 - e. MKT Fastening, LLC
 - f. Powers Fasteners
 - g. Caddy/Erco

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Routing: Unless otherwise indicated piping shall be installed within ceiling spaces or wall construction. Horizontal piping shall be run parallel to or at right angle to walls; risers shall be installed perpendicular to floors and ceilings.
- B. Expansion: Piping shall be installed generally as shown on the drawings with due allowance for expansion and contraction between installation and operating temperature extremes. Expansion loops as required shall be provided with approved anchors and guides. Takeoffs for water connections from mains shall be made with swing joints. See separate paragraph for EXPANSION JOINTS. Where expansion joints are used, anchors and guides shall be installed. First guide shall be no more than four (4) pipe diameters from joint; second guide shall be no more than 14 diameters from joint; remainder of guides and anchors shall be in accordance with "Standards of the Expansion Joint Manufacturers Association Inc." Piping and expansion joints shall be cold set as required to allow expansion to be compensated in expansion joints without overstressing joints and piping system.
- C. Pitch: Piping shall be pitched for proper drainage and air elimination. In general, the following shall apply:
 1. Steam piping shall be pitched downward 1 inch per 40 ft. in the direction of steam flow.
 2. Steam condensate piping shall be pitched downward 1 inch per 40 ft. in the direction of flow.
 3. Drainage piping shall be pitched downward a minimum of 1/8 inch per foot in the direction of flow.
 4. Water piping shall be pitched upward 0.5 percent in the direction of flow.

5. Where piping must change elevation to avoid structural or other obstruction, drain valves and air vents shall be provided for water piping and drip traps shall be provided for steam piping.
- D. Drain Valves: Provide 1/2 inch drain valves with 3/4 inch hose end connections at low points of heating hot water, chilled water and condenser water lines where required for complete system drainage. Valves shall be provided with screw-on caps.
- E. Air Venting: Provide air vents at high points of piping and equipment of heating hot water, chilled water and dual-temperature water systems. Vents must be installed where accessible and shall be manual 1/4 inch brass solder or screwed-end ball valves rated for 600 psi WOG. Provide 1/4 inch soft copper tube extension to drains or to a point where water may be easily collected.
- F. Shutoff and Isolation Valves: Provide shutoff valves at main branch connections, at items of equipment, and at bottom of risers where they originate from a continuous main and rise to a floor or floors above. Valves shall be line size.
- G. Gas and Relief Vent Pipe Terminations: Gas and relief vent pipes shall terminate at least 3 ft. above and at least 10 ft. horizontally from windows and outside air intakes, vent openings, etc. Provide vent caps at termination of pipe.
- H. Gas Piping Below Slab on Grade: All gas piping buried below or in concrete floor slab shall be double piped with no taps below slab. (Optional method of installation of using steel floor trench with cover will be considered by Architect/Engineer at Contractors request.) No direct buried pipe will be allowed. Casing pipe shall be Schedule 40 black steel.
- I. Cutting and Threading: Steel pipe with threaded joints shall have full cut, clean taper threads.
- J. Joints (Steel):
 1. Black steel pipe shall have screwed joints for sizes 2-1/2 inch and smaller and welded or flanged joints for pipes 3 inch and larger. Mechanical joints may be used on selected services 2-1/2 inch and larger as specified under Article MECHANICAL COUPLINGS. Where mechanical couplings are used, piping shall be cut grooved or roll grooved in accordance with manufacturer's specifications and instructions. Contractor shall have the option to weld piping 2-1/2 inch and smaller with specific permission of the Engineer
 2. Flanges shall be weld-neck type and of same pressure class as the valves installed. Flange gaskets shall be compressed composition type for steam piping and "red rubber" type for water services. Gaskets by Garlock or J.M. will be acceptable.
 3. Threaded pipe joints shall be made with an approved pipe thread compound applied to the male threads only.
- K. Welding:
 1. Perform welding of piping systems with qualified welders and welding operators. Welding shall be done in accordance with the applicable sections of ASME/ANSI B31.1 "Power Piping" and ASME/ANSI B39.9 "Building Services Piping" based on the type of service and pressure required. Qualify welding procedures, welders and welding operators in accordance with the ASME Boiler and Pressure Vessel Code Section 1X. Qualification records, in accordance with the ASME Code, shall be maintained.
 2. Shop fabricate major assemblies to keep field welding to a minimum. Leave one field weld in horizontal, vertical and lateral runs of pipe in each line for field adjustments.
 3. Prepare, clean, align, and space girth butt weld ends in accordance with Code. Chip, file and wire brush each weld.
 4. Grind all welds flush with inside diameter of pipe at flanges required for installation of orifice plates, vortex or turbine meters.
- L. Joints (Copper):
 1. Copper piping shall have sweat joints, except at valves where sweat to threaded adapters shall be used. Solder shall be of composition indicated below:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- a. Type 95; 95 percent Sn, 5 percent Sb.
 - b. Type S; 15 percent Ag, 80 percent Cu, 5 percent P.
- 2. Applications:
 - a. HAC Services: Mains, branches and risers shall be Type S. Runouts to terminal units may be made with Type 95. See Division 22 for plumbing work.
 - b. Refrigeration Piping: Type S.
- M. Fittings:
 - 1. Changes in direction and size of pipe shall be made with fittings. No mitering, saddling or welding of smaller pipe into larger will be permitted. Runouts in steel piping one-half the size of the main or smaller may be made by use of Weld-O-Lets; runouts larger than one-half main size shall be made with tees.
 - 2. No direct connection between dissimilar materials will be permitted. Connections are permitted between brasses or bronze and steel pipe if the water is properly treated and if the connections are in a closed system. For screwed connections, use insulating dielectric unions. For flanged connections, flange on copper side shall be bronze, and flange on steel side shall be ferrous material. Flanges shall be separated by means of gasket material and the thru-bolts shall be isolated from the boltholes by means of insulating bushings or grommets. The insulating portion of dielectric fittings and of field fabricated flange type dielectric joints shall not be painted.
 - 3. Unions: Unions shall be provided at connections to equipment unless the connections are made with flanged fittings or mechanical couplings.
 - 4. Escutcheons: Escutcheon plates shall be provided at penetrations of walls, ceilings, floors, etc., where pipe is exposed.

3.2 SUPPORTS AND HANGERS

- A. Piping and equipment shall be securely supported or suspended to avoid sagging, vibration and undue strain on pipes and equipment. Supports and hangers shall be supported from structural members, slabs and walls as strength permits. Use of electrical conduit or busways or the use of piping of other trades will not be allowed for use as supporting elements for this contract's pipe and equipment.
- B. Vertical pipes shall be supported at the bottom on base elbows or floor stands fastened to concrete piers and at each floor by riser clamps.
- C. Piping and equipment supported from structure above shall be supported from approved inserts, expansion shields or beam clamps as applicable. Contractor shall be responsible for the installation of all inserts, expansion shields and beam clamps required for the installation of all piping and equipment furnished under the contract and shall consult with the appropriate trades to determine the proper insert or shield to be used. Provide Unistrut, Caddy/Erco or equal channels attached with at least two (2) bolts with expansion shields for all inserts omitted. Single point support will not be acceptable. Under no circumstances will welding of hanger rods to structural members be permitted. When required, provide Unistrut, Caddy/Erco or equal channels for proper support. Channels shall be galvanized when used as inserts in concrete or when used as pipe racks in tunnels. Elevated piping and equipment supported from floors shall be provided with pipe stands or structural steel support frames as required. Piping supported off roof shall be provided with a means of support to elevate piping a minimum of 6 inch off finished roof to bottom of piping or insulated piping. Supports shall be flashed into roofing as required to provide a watertight installation. Caddy/Erco or RPS pipe mounting pedestals may be used. Assembly shall include equipment rail, steel slide channel attached to rail with mounting brackets and adjustable height pipe roller with retainer bracket and miscellaneous hardware to form a complete pipe support assembly. Piping installed on existing roofs may be supported with Miro Industries or Caddy/Erco pillow block pipe stands. Pipe stands shall be made of polycarbonate with edges rounded to prevent penetration of membrane roofing.
- D. No cutting of structural members is permitted unless written permission is obtained from the Architect/Engineer.

- E. Hangers shall be trapeze, split ring or clevis type on adjustable rods. Hangers in direct contact with copper tubing shall be copper plated. Straphangers will not be permitted. Hanger rods constructed of all thread shall be cadmium plated.

- F. Spacing of pipe hangers shall comply with the following schedule:

Size of Pipe	Spacing of Hangers max. ft.	
	Copper	Steel
1/2 inch	6	8
3/4 inch to 1 inch	8	8
1-1/4 inch to 3 inch	10	10
4 inch and over.....	12	12

- G. Pipes shall be anchored at points where there is a change in direction or at points where branch lines connect to a main line as required to prevent any strain on the branch line.

- H. Roller type hangers shall be used on hot water lines 4 inch and larger. Where roller hangers are used, hanger rods shall be braced to prevent lateral movement.

- I. Vibration Isolation Hangers: Pipe hangers supporting pipes subject to the transmission of vibration shall be of the vibration isolation type. See Section 232400 - VIBRATION AND SEISMIC CONTROL.

- J. Trapeze Hangers may be used for group of pipes.

- K. Supports for Piping Racked on Channel Supports in Tunnels:

1. Channel supports used for racking pipes in tunnels shall be galvanized, epoxy coated or have electro-chromate finish. Floor-supported pipe racks shall be installed on 2 inch concrete pad.
2. Pipe rollers shall be installed at each point of pipe support and shall be similar to Unistrut Series P2474-1 through 4 for piping up to 6 inch, Unistrut Series P2475 for piping through 12 inch and Unistrut Series P2476 for piping over 12 inch in diameter. Similar pipe rollers by Caddy/Erco will be acceptable. Piping shall be provided with saddles at support points.
3. Piping shall be anchored and expansion joints shall be installed where necessary to properly compensate for expansion.
4. Pipe guides shall be installed at points of support where indicated and as required. Guides shall be of the spider type and the outer housing shall be secured to the channel supports as required to maintain the proper pipe elevation. The spider shall be attached directly to the pipe, and the entire pipe and spider assembly shall be completely insulated.
5. Piping that is not subject to expansion and which is not installed with expansion joints or loops, such as domestic cold and hot water, drain and sanitary waste, etc., may be secured with pipe clamps installed over insulation shield of galvanized steel.
6. Channel supports and accessories shall be by Unistrut as specified above or equivalent by Superstrut, Caddy/Erco or B-Line.

- L. Supports for Piping Racked on Channel Supports Associated with Casework:

1. All channel supports shall be factory finished.
2. Piping shall be secured with pipe clamps designed for the service involved.
3. Channel supports and accessories shall be by Unistrut, Superstrut, Caddy/Erco or B-line.

- M. Seismic bracing shall be provided in accordance with Section 232400 - VIBRATION AND SEISMIC CONTROL.

3.3 PIPE TESTING

- A. Pressure test piping before covering by means of hydrostatic or pneumatic methods (see respective section) at a pressure not less than 50 percent above operating pressure of system, but in no case less than pressures specified below. NOTE: Plastic piping (PVC, CPVC, PP, etc.) should only be tested hydrostatically. Isolate or remove control devices not designed to

withstand test pressure from piping prior to pressure test. Defective welds found in welded piping shall be ground off and rewelded. Defective screwed, mechanically coupled and soldered joints shall be disassembled, cleaned and rejoined as a new joint. After repairing defects, piping shall be retested as required to ensure a tight system.

1. Refrigerant Piping: Unless factory pretested as a package, refrigerant piping shall be pneumatically tested with nitrogen or approved equal dry inert gas at a pressure not less than 300 psi on the high-pressure side and not less than 150 psi on the low-pressure side. Pressure shall be retained on system with no drop in pressure for 24 hours, except as produced by changes in temperature; 0.3 psi per F. temperature change of ambient air. System, except the receiver, shall then be evacuated to a vacuum of 29.6 inch of mercury and shall hold vacuum for a period of 1 hour. Provide refrigerant and oil required to completely charge all systems. Provide oil and refrigerant required due to defects in labor and material for a period of 1 year from date of Owner's acceptance.
2. Water and Glycol Piping: shall be hydrostatically tested at no less than 50 percent above operating pressure of system. Pressure in the section of piping under test shall be maintained for a period of time sufficient to inspect every joint in the test section and for no less than 4 hours without evidence of leakage or change in pressure. The above does not apply to domestic water systems; see Division 22.
3. Gas Piping shall be pneumatically tested with compressed air or Nitrogen at a minimum of 25 psi and in no case less than 50 percent above operating pressure of system. Pressure in the section of piping under test shall hold constant for a period of 24 hours after applying correction factors for ambient temperature changes. Where required by code or utility company, a certificate of compliance shall be obtained from utility company or code-enforcing authority.
4. Sewer and Sanitary Piping: See Division 22.

3.4 CLEANING OF PIPING

- A. System components and piping shall be thoroughly cleaned in accordance with the following provisions:
 1. Hot Water, Chilled Water and Glycol Solution Systems: Piping may be field cleaned as specified below utilizing temporary pumping facilities or piping may be shop cleaned and delivered to site in cleaned condition and capped. Shop cleaning shall be equivalent to cleaning process specified below.
 - a. Initially fill and flush system with water.
 - b. Fill system with fresh water.
 - c. Add American Water Conditioning No. 650 alkaline cleaner at the prescribed level.
 - d. Raise temperature of water to that for normal operation, but not higher than 200 deg. F. or maximum operating temperature of system.
 - e. Circulate water in system for 8 hours at operating temperature. All parts of system must be open to assure free circulation.
 - f. Flush system by adding fresh makeup water until water at overflow is clean and until phosphate level is down to 10 ppm.
 - g. Drain: Give particular attention to low points in system to be certain that foreign matter has been entirely removed.
 - h. Open strainers and clean strainer elements. Blowing down through blow-down openings will not be acceptable.
 - i. Refill with fresh water and add American Water Conditioning #139 nitrite borate corrosion inhibitor to reach a level as recommended by water treatment manufacturer.
 2. Specialty Piping System: Piping for specialty systems shall be cleaned in accordance with manufacturer's recommendations or as governed by applicable code.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

3.5 GENERAL

- A. See PART 2 for other installation details.

END OF SECTION 230600

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SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

- 1. General Commissioning Requirements for HVAC Systems and Equipment
- 2. HVAC Systems to be Commissioned

B. Related Requirements:

- 1. Section 019113 "General Commissioning Requirements".
- 2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. DDC: Direct digital controls.
- E. HVAC: Heating, ventilating, and air conditioning.
- F. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.
- G. TAB: Testing, adjusting, and balancing.

1.4 SUBMITTALS

A. Action Submittals

- 1. Where required in Division 23 specifications; provide the CxA with actions submittals for all commissioned systems identified in this section.

B. Informational Submittals

- 1. Pre-Functional Checklists, Start-Up Forms, and Test Reports: Where required in Division 23 specifications; provide the CxA material, installation, and performance test checklists

for systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section. Note that Pre-Functional Checklists shall be completed prior to any Functional Performance Testing.

C. IOM Manuals

1. The contractor shall provide the CxA with Installation and Operation Manuals of systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section

D. Closeout Submittals

1. Where required in Division 23 specifications; provide closeout submittals for all commissioned systems identified in this section.

1.5 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians to perform BAS construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. HVAC Testing Technician Qualifications: Technicians to perform HVAC construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

C. Testing Equipment and Instrumentation Quality and Calibration:

1. Capable of testing and measuring performance within the specified acceptance criteria.
2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
3. Be maintained in good repair and operating condition throughout duration of use on Project.
4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SYSTEMS TO BE COMMISSIONED

- A. Building Automation System (s)
 - 1. Automated Logic
 - 2. Laboratory System
- B. Primary Building Air Handling System
 - 1. Air Handlers
 - 2. Heat Recovery System
 - 3. Associated Terminal Boxes (VAV, CAV, EXH, etc)
- C. Cadaver Lab HVAC System
 - 1. Air Handlers
 - 2. Exhaust Fans
- D. Telecom Room HVAC Systems
 - 1. Fancoil or DX Units
- E. Building Hot Water Heating System
 - 1. Boilers
 - 2. Pumps
- F. Building Chilled Water Cooling System
 - 1. Existing EAB Chiller Plant – Not Included
 - 2. Pumps
- G. Exhaust Systems
 - 1. Laboratory Exhaust Fans
 - 2. Fume Hoods
 - 3. General Exhaust Fans
 - 4. Kitchen Exhaust Fans
 - 5. Relief Fans
 - 6. Associated Terminal Boxes (EXV, EHV, etc)
- H. Instrumentation and Controls associated with all of the above.

3.2 CX TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.

- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.3 CX TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 CX TESTS COMMON TO HVAC SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Construction checklist verification tests.
 - 2. Construction checklist verification test demonstrations.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

3. Cx tests.
4. Cx test demonstrations.

END OF SECTION 230800

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INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 231900 – MECHANICAL IDENTIFICATION

Article	Title	Page
PART 1 - GENERAL		1
1.1	RELATED DOCUMENTS	1
1.2	SUMMARY	1
1.3	GENERAL IDENTIFICATION REQUIREMENTS	1
1.4	DESCRIPTION OF REQUIRED IDENTIFICATION	1
1.5	SCOPE OF WORK	1
1.6	SUBSTITUTIONS	1
1.7	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.8	QUALITY ASSURANCE	2
1.9	SYSTEM DESCRIPTION	2
1.10	COORDINATION	2
PART 2 - PRODUCTS		2
2.1	EQUIPMENT IDENTIFICATION DEVICES	2
2.2	PIPING IDENTIFICATION DEVICES	3
2.3	VALVE TAGS	3
2.4	DUCT IDENTIFICATION DEVICES	3
2.5	WARNING TAGS	3
PART 3 - EXECUTION		4
3.1	GENERAL	4
3.2	PREPARATION	4
3.3	EQUIPMENT IDENTIFICATION	4
3.4	PIPING IDENTIFICATION	4
3.5	VALVE TAG INSTALLATION	5
3.6	DUCT IDENTIFICATION	5
3.7	WARNING TAG INSTALLATION	5
3.8	ADJUSTING	6
3.9	CLEANING	6
3.10	EXISTING SYSTEMS	6

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SECTION 231900 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections apply to this Section.
- B. Requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to this Section.
- C. See the following specification sections for equipment, piping and valve specifications that are required for this project and that are to be identified in accordance with this specification section:
 - 1. Section 230100 - BASIC MECHANICAL REQUIREMENTS
 - 2. Section 230500 - BASIC MECHANICAL MATERIALS AND METHODS
 - 3. Section 230600 - PIPING
 - 4. Section 235000 - HAC EQUIPMENT
 - 5. Section 238800 - AIR DISTRIBUTION
 - 6. Section 239500 - CONTROLS AND INSTRUMENTATION

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 - 1. Equipment nameplates
 - 2. Access panel and door markers
 - 3. Pipe markers
 - 4. Valve tags
 - 5. Duct markers
 - 6. Warning tags

1.3 GENERAL IDENTIFICATION REQUIREMENTS

- A. This section is intended to cover identification of mechanical equipment, valves and piping as applicable to heating and air conditioning, plumbing and fire protection work.
- B. Contractor shall include labor and material for identification of work as herein specified and as required for complete and proper labeling of material, equipment and systems.

1.4 DESCRIPTION OF REQUIRED IDENTIFICATION

- A. See PART 2 of this specification section.

1.5 SCOPE OF WORK

- A. See PART 3 of this specification sections.

1.6 SUBSTITUTIONS

- A. No substitutions will be allowed except as specified in Section 230100.

1.7 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Comply with Section 230100.
- B. LEED Submittal:
 - 1. Product Data for Credit EQ 4.1: For adhesives, sealants and sealant primers, including printed statement of VOC content.
- C. Product Data: For each type of product indicated.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- D. Valve Schedules: For each piping system provide a valve schedule binder with each page plastic protected. Valve schedules shall include valve number, type of service, location, specific area or equipment served. Three (3) copies of schedules, separately bound, are required to include in maintenance manuals.

1.8 QUALITY ASSURANCE

- A. ASME Compliance (Latest Edition): ASME A13.1, "Scheme for the Identification of Piping Systems."
- B. ASME Z53.1 (Latest Edition) "Safety Color Code for Marking Physical Hazards."
- C. NFPA 99 (Latest Edition) "Gas and Vacuum Systems."
- D. CGA, Compressed Gas Association Standard (Latest Edition).

1.9 SYSTEM DESCRIPTION

- A. Color Coding and Nomenclature for Building Piping: Conform to ANSI A13.1

1.10 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied. Refer to Division 09 PAINTING, and PAINTING article of 230500.
- B. Coordinate installation of identifying devices with location of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Mechanical identification nomenclature shall match Contract Documents as well as existing mechanical identification nomenclature. Notify Engineer of any discrepancies. Contractor shall not install any mechanical identification until all discrepancies are resolved by Engineer.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Nameplates shall be 1/16 inch thick white core, black surface, laminated plastic with beveled edges. (Contractor shall verify color preference with Facilities Manager prior to ordering nameplates.)
 - 1. Data: Plan mark corresponding to drawing designation.
 - 2. Engraving: Lettering shall be 3/16 inch high, minimum 6 letters per inch wide, with 3/16 inch spacing between words. Where two (2) lines of lettering are required, separate lines of text by 3/16 inch space. Center lettering on nameplate.
 - 3. Size: Minimum 2-1/2 inch x 4 inches for control devices, dampers, and valves; minimum 4-1/2 x 6 inches for equipment.
 - 4. Fasteners: Self-tapping, stainless steel screws or contact-type, permanent adhesive.
- B. Volatile Organic Compound (VOC) Content:
 - 1. VOC Content of Adhesives, Sealants and Sealant Primers: Provide products that comply with the VOC limits listed in South Coast Air Quality Management District (SCAQMED) Rule #1168, effective date of July 1, 2005 and rule amendment date of January 7, 2005.
- C. Plastic Tape Access Panel and Door Markers: Material No. B-946, flexible vinyl film tapes with pressure sensitive permanent adhesive backing and printed markings.
 - 1. Suitable for indoor/outdoor application.
 - 2. Temperature Range: Minus 40 deg. F. to 180 deg. F.
- D. Letter style block, 2 inches high minimum.

2.2 PIPING IDENTIFICATION DEVICES

- A. **Manufactured Pipe Markers, General:** Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 - 5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
- B. **Pretensioned Pipe Markers:** Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive. Piping 3/4 inch through 5 inch diameter.
- C. **Shaped Pipe Markers:** Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with nylon ties that do not penetrate insulation vapor barrier. Piping 6 inch diameter and larger.
- D. **Manufacturer:** Identification devices manufactured by Seton Identification Products. Pipe markers by W.H. Brady or Marking Services or Craftmark meeting the above specification will be considered for approval.

2.3 VALVE TAGS

- A. **Tags** shall be brass, aluminum or laminated phenolic, approximately 1 inch in diameter and shall be fastened to valve by heavy beaded chains or S-rings. Laminated phenolic tags shall be provided in one consistent color for all systems unless otherwise indicated. Valve tags shall be inscribed with identifying number pre-fixed as follows:
 - 1. For Heating and Air Conditioning Services use "H"
 - 2. For Laboratory Services use "L"
- B. **Manufacturer:** Identification devices manufactured by Seton Identification Products. Pipe markers by W.H. Brady or Marking Services or Craftmark meeting the above specification will be considered for approval.

2.4 DUCT IDENTIFICATION DEVICES

- A. **Duct Markers:** Durable, self-adhesive vinyl of one consistent color for all systems. Include direction of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.
- B. Letter style block, 2 inches high minimum.
- C. **Hazardous Material Exhaust:** ASME 13.1 Colors and Design.
- D. **Manufacturer:** Identification devices manufactured by Seton Identification Products. Pipe markers by W.H. Brady or Marking Services or Craftmark meeting the above specification will be considered for approval.

2.5 WARNING TAGS

- A. **Warning Tags:** Preprinted 1/16 inch thick laminated plastic with beveled edges, accident-prevention tags.
 - 1. Size: 3 by 5-1/4 inches minimum.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER STARTS AUTOMATICALLY."
 - 4. Color: Conform to ANSI Z35.1.

- B. Manufacturer: Identification devices manufactured by Seton Identification Products. Pipe markers by W.H. Brady or Marking Services or Craftmark meeting the above specification will be considered for approval.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide pipe identification, valve tags, or engraved nameplates to clearly identify the mechanical equipment, piping, ductwork, and controls of the various mechanical systems and direction of flow in piping.
- B. Coordinate installation of all identification with Division 09 and Division 23 PAINTING and work of other trades. Contractor shall be required to relocate, repair or replace any identification obscured by other work.

3.2 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.3 EQUIPMENT IDENTIFICATION

- A. Equipment Nameplates: Install with stainless steel self-tapping screws or permanent adhesive on or near each major item of mechanical equipment. Nameplates as specified in PART 2 of the specification section.
 - 1. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fire protection equipment such as: pumps, air compressors, control panels, storage tanks, release panels, etc.
 - c. Meters, gages, thermometers, and similar units.
 - d. Fuel-burning units, including boilers.
 - e. Pumps, compressors, and similar motor-driven units.
 - f. Heat exchangers, coils, evaporators, heat recovery units, and similar equipment.
 - g. Fans, blowers, primary balancing dampers, and mixing boxes.
 - h. Packaged HVAC equipment, including air handling units, and concealed zone-type units.
 - i. Tanks and pressure vessels.
 - j. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
 - 2. Location: Accessible and visible.
 - 3. Coordinate installation of equipment identification with Division 09 Painting.
- B. Access Panel and Door Markers: Install with screws on equipment access panels in accessible and visible location.

3.4 PIPING IDENTIFICATION

- A. General: Install pipe markers and flow arrows in accordance with manufacturer's instructions. Locate all pipe markers and flow arrows accessible and visible. For overhead piping, apply pipe marker on lower half of the pipe where view is unobstructed so marker can be read from floor level. Locate pipe markers and flow arrows where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:
 - 1. Within 3 inches of each valve and control device.
 - 2. Within 3 inches of each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Within 3 inches of penetrations through walls, floors, ceilings, and non-accessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 ft. along each run. Reduce intervals to 25 ft. in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.
 8. If flow can be in both directions, use double-headed flow arrow.
 9. Use flow arrow marker with each pipe marker. Flow arrow shall point in direction of flow; color and height of flow arrow shall be same size as pipe marker lettering.
 10. Steam piping, condensate return, compressed air, gas and vacuum systems shall include working pressure or vacuum.
- B. Install manufactured pipe markers for indoor use indicating service on each piping system. Install with flow indication arrows showing direction of flow.
1. Pretensioned Pipe Markers: Pipes with OD, including insulation, less than 6 inches. Use size required to ensure a tight fit.
 2. Shaped Pipe Markers: Pipes with OD, including insulation, 6 inches and Larger. Use size to match pipe and secure with nylon ties to not penetrate insulation vapor barrier.
 3. Exterior and High Humidity Locations: Install high performance pipe markers in accordance with manufacturer's instructions. Piping 6 inch diameter and larger shall be installed with nylon ties not to penetrate insulation vapor barrier.
 4. Install non-detectable plastic warning tape 12 inches below finish grade and directly above buried utility. Visually inspect warning tape prior to backfilling to ensure tape is continuous and not cut. Coordinate installation of warning tape with installation of underground piping tracer wire specified in Section 230600.
- C. Install underground pipe warning tape above all buried utilities within the scope of this contract.
1. Use detectable tape for applications in which the buried utility is non-metallic.
 2. Use non-detectable tape for applications in which the buried utility is metallic and is detectable by a non-ferrous locator.
- 3.5 VALVE TAG INSTALLATION
- A. Install tags on valves, circuit setters and control devices in piping systems. List tagged valves in maintenance manual valve schedule.
1. Exception: Check valves; valves within factory-fabricated equipment units; plumbing fixture supply stop valves at fixtures; faucets; convenience and lawn-watering hose connections; needle valves; local drip valves and air vents at equipment and similar appurtenances.
- B. Attach tag to bonnet of screwed end valves and to handwheel spoke of flanged OS&Y valves. Provide tags for all valves remote from equipment including remote drip valves and air vents.
- 3.6 DUCT IDENTIFICATION
- A. Install duct markers and flow arrows in accordance with manufacturer's instructions.
- B. Provide duct markers and flow arrows in one consistent color for all systems.
- C. Hazardous materials exhaust ASME 13.1 Colors and Design.
- D. Locate duct markers near points where ducts enter into concealed spaces and at maximum intervals of 50 ft. in each space where ducts are exposed or concealed by removable ceiling system.
- 3.7 WARNING TAG INSTALLATION
- A. Attach warning tags to equipment and other items where required.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- B. Attach warning tag "EMERGENCY GAS SHUTOFF VALVE" at 5 ft.-0 inch A.F.F. beside emergency shutoff valve.
- C. Install warning marker "EMERGENCY BOILER SHUTDOWN" at remote boiler shutdown switch.

3.8 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.9 CLEANING

- A. Clean faces of mechanical identification devices.

3.10 EXISTING SYSTEMS

- A. Provide new mechanical identification on existing piping and ductwork within 10 ft. (3 M) of tie-in to new systems.

END OF SECTION 231900

INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 232400 – VIBRATION AND SEISMIC CONTROL

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	RELATED DOCUMENTS	1
1.3	SUMMARY	1
1.4	DEFINITIONS	1
1.5	PERFORMANCE REQUIREMENTS	1
1.6	COORDINATION	2
1.7	SUBSTITUTIONS	2
1.8	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
1.9	MANUFACTURER'S RESPONSIBILITY	3
1.10	QUALITY ASSURANCE	5
PART 2 - PRODUCTS		5
2.1	MATERIAL QUALIFICATIONS	5
2.2	FACTORY FINISHES	6
2.3	DESIGN REQUIREMENTS	6
2.4	TYPE OF ISOLATION	7
2.5	SEISMIC SNUBBERS	9
PART 3 - EXECUTION		10
3.1	INSTALLATION	10
3.2	SEISMIC REQUIREMENTS	11
3.3	ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION	12
3.4	INSPECTION	12
3.5	GENERAL INSTALLATION OF VIBRATION ISOLATORS FOR EQUIPMENT	13
3.6	INSTALLATION OF SUSPENDED EQUIPMENT VIBRATION ISOLATORS	13
3.7	INSTALLATION OF DUCTWORK VIBRATION ISOLATION	13
3.8	INSTALLATION OF PIPING VIBRATION ISOLATORS	13
3.9	INSTALLATION OF SEISMIC ROOF CURB	14
3.10	INSPECTION OF VIBRATION AND SEISMIC CONTROL	14
3.11	VIBRATION SCHEDULE FOR MECHANICAL WORK	15

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SECTION 232400 - VIBRATION AND SEISMIC CONTROL

PART 1 - GENERAL

1.1 REFERENCES

- A. Division 01, GENERAL REQUIREMENTS, and requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to work under this specification section.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 230100 - BASIC MECHANICAL REQUIREMENTS apply to this Section.

1.3 SUMMARY

- A. Provide vibration control and seismic restraints for Division 23 work.
- B. Furnish submittals including details, design calculations, schedules, shop drawings, certifications and sealed cover letter for vibration isolation and seismic restraint.
- C. Isolate vibration generating equipment from building structure by means of vibration isolators. Do not rigidly connect system components, such as piping and conduit, to vibration generating equipment unless these components are isolated through flexible connectors or vibration eliminating hangers.
- D. Provide vibration isolators to isolate main piping and ducts within mechanical equipment rooms from building structure. Isolate additional length of pipes and ducts as specified herein and as noted on drawings.
- E. Coordinate Work to avoid rigid contact to components installed by other trades. Provide corrective work necessitated by conflicts due to incorrect installation.
- F. Correct variance or non-compliance with the specifications at no additional cost.

1.4 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.
- D. Qualified Professional Engineer: An engineer experienced in seismic design, registered and licensed to practice engineering in the state of Missouri.

1.5 PERFORMANCE REQUIREMENTS

- A. Wind Restraint Loading:
 - 1. Basic Wind Speed: As indicated on Structural Drawings.
 - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
- B. Code Compliance: Seismically brace Work in accordance with 2009 IBC, Authorities Having Jurisdiction and as indicated on the Seismic Code Block on the drawings. Component Importance Factor for calculating seismic forces shall be as indicated on Seismic Code Block.
- C. Work in this section includes labor, material, tools, appliances and equipment necessary for a complete vibration isolation and seismic restraint installation as indicated on drawings and in compliance with the specifications of this section. Forces shall be calculated for individual supports based on the following project criteria:

1. The total height of the structure and the height of the equipment or system to be restrained within the structure shall be determined by coordination with the Architectural Plans and the General Contractor.
2. Occupancy Category: As indicated on Seismic Code Block.
3. Seismic Design Category: As indicated on Seismic Code Block and Structural Drawings.
4. Site Classification: From geotechnical report: B.
5. Spectral Response Acceleration (S_1): 0.18 – St. Louis County.
6. Spectral Response Acceleration (S_s): 0.54 – St. Louis County.
7. Component Importance Factor for calculating seismic forces shall be as indicated on the Seismic Code Block.

1.6 COORDINATION

- A. Coordinate vibration isolation and seismic restraints with final equipment selections.
- B. Coordinate housekeeping pad sizes specified in Section 230500 - BASIC MECHANICAL MATERIALS AND METHODS with anchor bolt edge clearance as detailed by vibration isolation and seismic restraint manufacturer and International Conference of Building Officials (ICBO).
- C. Coordinate with ductwork supports as specified in Section 238800 - AIR DISTRIBUTION for reinforcement of ductwork at seismic restraint connections.
- D. Coordinate with piping supports as specified in Section 230600 - PIPING for reinforced hangers at seismic restraint connections.
- E. Coordinate with controls supports as specified in Section 239500 - CONTROLS AND INSTRUMENTATION.
- F. In addition to the components identified on the drawings and in the specifications to be seismically braced, provide seismic bracing in accordance with International Building Code Referenced Standard ASCE 7-05 13.2.3 Consequential Damage.

1.7 SUBSTITUTIONS

- A. Substitutions will not be allowed except as specified in Section 230100 - BASIC MECHANICAL REQUIREMENTS.

1.8 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Submit shop drawings for vibration isolation/seismic restraint work in accordance with Section 230100, SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS article.
- B. Submittals shall be reviewed for compliance with specifications prior to submission.
- C. Submittal shall be complete for each mechanical, plumbing or fire protection discipline's work. Incomplete submittals will be rejected for resubmittal.
- D. Submittal shall include the following:
 1. Cover letter from Qualified Professional Engineer: Cover letter shall state that the Qualified Professional Engineer has reviewed seismic calculations, details and shop drawings for compliance with the project seismic performance requirements and seismic design criteria.
 2. Seismic restraint details, calculations and shop drawings. Details, calculations and shop drawings shall be signed and sealed by a Qualified Professional Engineer.
 3. Details of anchorage and seismic restraints of equipment and system components.
 4. Anchorage Details: Include the following:
 - a. Specific information relating to the type and size of anchorage (anchor bolts, etc.). Anchorage shall be certified by manufacturer that it is suitable for dynamic seismic forces.
 - b. Specific location of such anchorage.

- c. Details of sway bracing to include:
 - 1) Materials used for sway bracing.
 - 2) Attachment of the sway bracing to the structure and component being braced.
 - 3) Locations of transverse and longitudinal sway bracing and rod stiffeners.
- 5. Seismic design provided by Contractor's Qualified Professional Engineer shall meet requirements of Article 1.9 MANUFACTURER'S RESPONSIBILITY, of this specification.
- 6. Provide four (4) additional copies to quantities defined in Division 01.
- 7. Provide MEP permit number with submittal.
- 8. Submit Seismic submittals shall be submitted a minimum of 4 weeks prior to planned installation to allow for Engineer of Record's review, County's review and the County's distribution to County Inspector. Additional time may be needed if such submissions are deficient.

1.9 MANUFACTURER'S RESPONSIBILITY

- A. Manufacturer of vibration isolation and seismic restraints shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes, quantity, type and locations.
 - 2. Determine anchor bolts or other type fasteners and their embedment into building structure or concrete housekeeping pad.
 - 3. Coordinate design based on final equipment selection, and ductwork, piping and controls layout.
 - 4. Furnish calculations to determine restraint loads resulting from seismic forces.
 - 5. Furnish design analysis in accordance with seismic requirements per Building Code. The design analysis shall take into account the total height of the structure and the height of the equipment or system to be restrained within the structure as determined by coordination with the Architectural Plans and the General Contractor.
 - 6. Coordinate with the Structural Engineer of Record attachments and anchorage to the building structure.
 - 7. Detail attachments of seismic restraints to the restrained items and to the building structure. Show attachment locations, methods, and spacings. Identify seismic restraint components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - 8. Furnish certification that seismic restraints and hanger rods have the capability to safely support loads resulting from seismic forces determined by methods defined in paragraphs above. Certification must be substantiated by calculations or test reports verified by the Manufacturer's Qualified Professional Engineer.
 - 9. Furnish details, calculations and shop drawings signed and sealed by the Manufacturer's Qualified Professional Engineer.
 - 10. Provide vibration isolators, seismic restraints, attachment hardware and installation tools as shown or specified for a complete installation.
 - 11. Verify proper installation of vibration isolation and seismic restraints.
 - 12. Furnish material certification sheets and test reports upon request.
- B. Submittal Data Requirements:
 - 1. Product Data:
 - a. Catalog cuts or data sheets on vibration isolators and specific restraints details in compliance with the specification.
 - 1) Indicate application, style, material, strength, anchorage and finish for each type and size device.
 - 2) Include load rating, deflection rating and overload capacity for each device.
 - 3) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an

- evaluation service member of an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction.
 - 4) Seismic restraint devices shall be tested for horizontal and vertical loading and shall bear anchorage pre-approval OPA number from OSHPD, pre-approval by ICC-ES, or pre-approval by another agency acceptable to Authorities Having Jurisdiction, showing maximum seismic restraint ratings.
 - 5) Annotate to indicate application of each product submitted and compliance with requirements.
 - b. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
 - c. Detailed schedules of equipment, piping, ductwork and controls showing vibration isolators and seismic restraints by referencing numbered details.
2. Shop Drawings:
- a. Provide details of vibration isolators, and seismic restraints: include quantity, type, size and location of each. Details shall include design of attachment hardware, reinforcement, specific anchorage and installation with relation to the building structure, system or equipment.
 - b. Provide shop drawings indicating the locations and types of vibration isolators/seismic restraints and rod stiffeners with references to specific numbered descriptive drawing details. Shop drawings shall indicate method of attachment to the building structure with details of wall, floor or other building structure to which vibration isolators or seismic restraints are attached.
 - c. Submittal shall include spacing, static loads and seismic loads at attachment and support points.
 - d. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to building structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
3. Design Certification and Analysis:
- a. Seismic restraint calculations shall be provided for connections of vibration isolators and seismic restraint devices. Formulas and code references shall be included.
 - b. Calculate static and dynamic seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
 - c. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 sections for equipment mounted outdoors.
 - d. Analysis shall indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and the building structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/or weld length. Seismic restraint devices shall be designed with the appropriate factor of safety, to accept without failure, the forces detailed in this section of the specification acting through the equipment's center of gravity.
4. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
5. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints. If piping, ductwork or suspended equipment is specified to be supported with vibration isolation hangers, seismic sway bracing shall be with cable sway bracing only.
6. Welding certificates.

7. Seismic and Wind Restraint Details:

- a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
- b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
- c. Coordinate seismic restraint and vibration isolation details with wind restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
- d. Preapproval and Evaluation Documentation: By OSHPD, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.10 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Authorities Having Jurisdiction.
- B. Comply with seismic restraint requirements in Building Code stated in PART 1 of this Section unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic restraints shall be designed by a Qualified Professional Engineer or shall be from the most current edition of one of the following manuals considered as "Accepted Engineering Practice."
 1. Seismic Restraint Manual Guidelines for Mechanical Systems (published by SMACNA)
 2. Guidelines and Details that have been evaluated and reported under the International Code Council (ICC) Evaluation Service Program
 3. Seismic Restraint Manuals, Guidelines and Details that have been approved by the California Office of Statewide Health Planning and Development (OSHPD) under their pre-approval program for anchorage and sway bracing systems.

PART 2 - PRODUCTS

2.1 MATERIAL QUALIFICATIONS

- A. Equipment shall bear manufacturer's name, trademark, ASME, UL, and other labels where a standard has been established.
- B. Equipment shall be latest approved design of standard cataloged items with factory-certified ratings.
- C. General Requirements for Seismic Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES, OSHPD or signed/sealed by Qualified Professional Engineer as defined in PART 1 of this Section. Seismic restraints shall be selected for final equipment selection.
 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of anchorage shall be at least four (4) times the maximum seismic force to which they will be subjected as defined in code requirements for each type of seismic restraint.
- D. General Requirements for Vibration Isolation: Support equipment, piping and ductwork as noted in the specification with vibration isolation to prevent transmission of vibration and mechanically transmitted sound. Select vibration isolators in accordance with the weight distribution of final equipment selection so as to produce uniform deflections.

- E. Manufacturers: Vibration isolation and seismic restraints shall be by Mason Industries, Inc. Vibration isolation and seismic restraints by California Dynamics Corp., B-Line Systems, Amber-Booth, Loos or Tolco meeting the above specifications will be considered for approval. All vibration and seismic restraints shall be by one manufacturer.
- F. Restraint Cables: ASTM A 603 galvanized steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two (2) clamping bolts for cable engagement.
 - 1. Sway Bracing Cable: Sway bracing cable (wire/rope) strength shall exceed the maximum combined horizontal and simultaneous vertical force determined by the applied load, safety factor and angle of the cable when installed.
- G. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- H. Anchorage of Seismic Restraints: Anchorage of seismic restraints shall be approved by the seismic restraint manufacturer specifically for the dynamic seismic loads and as tested according to ASTM E488. Such approval shall be submitted to the Engineer.

2.2 FACTORY FINISHES

- A. Provide vibration isolators and seismic restraints located indoors with manufacturer's standard baked enamel or powder coated finish unless otherwise noted.
- B. Vibration isolators and seismic restraints located outdoors or indoors in wet or damp locations shall be designed or treated for resistance to corrosion.
- C. Steel components shall be PVC coated, or phosphated, and painted with industrial grade enamel. Nuts, bolts and washers shall be zinc-electroplated for exterior use or stainless steel. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. Finish coat of gray industrial alkyd enamel shall be applied over primer.
- D. Isolators exposed to weather shall have steel parts PVC coated or zinc-electroplated with an additional coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall be suitably weatherproofed etched and painted with industrial grade enamel.

2.3 DESIGN REQUIREMENTS

- A. Steel springs shall be of stable type, having horizontal stiffness at least equal to vertical stiffness. Shear stress at solid shall be sufficiently low that spring does not exceed its elastic limit and shall be certified by manufacturer for infinite cycle life classification.
- B. Floor-mounted spring isolators shall be of housed or semi-housed type for seismic restraint or of unhoused type utilized with separate seismic snubbers. Limit stops shall be provided to limit excessive vertical motion of the supported equipment when the load is reduced or when subjected to torquing or external forces. Floor mounts may be of single or multi-spring type so designed to concentrate supported load at center of support. Floor-mounted isolators shall be equipped with ribbed neoprene pad bonded to underside of baseplate. Floor mounts shall be selected so that no more than 1 inch of adjustment is required to level equipment.
- C. Hangers shall be of open or box type. Metal-to-metal contact between hanger rods and hanger box components shall be prevented through design of spring diameters and hanger box hole size, to permit hanger rod to swing through a 30 degree arc before contacting metal and short-circuiting spring. Box hangers shall be designed to withstand temporary loading equal to 400 percent of rated design load without visible deformation or failure.
- D. Where isolator mounts for floor-mounted equipment are required to be attached to equipment, frames or bases, the mounts shall be attached in a manner to maintain operating clearance of 3/4 to 1-1/2 inch under equipment base or frame.

- E. Spring isolators supporting a given piece of equipment shall be selected on basis of equal spring deflection. Therefore, spring isolators should compensate for unequal loading at various isolator locations. Equipment shall be level after operating load is applied.
- F. Isolators for equipment to be installed outdoors shall be designed to provide adequate restraint to withstand wind loading of 30 psf applied in any direction without failure of isolator.

2.4 TYPE OF ISOLATION

- A. Type A: Neoprene Mounts: Double deflection, minimum static deflection of 0.35 inches. All metal surfaces shall be covered with neoprene and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Mountings shall be equal to Type ND as manufactured by Mason Industries, Inc.
- B. Type B: Spring Mounts: Freestanding and laterally stable without any housing or snubbers and complete with a molded neoprene cup or 1/4 inch neoprene acoustical friction pad between the baseplate and the support. Mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be equal to Type SLF as manufactured by Mason Industries, Inc.
- C. Type C: Spring Mounts with Stops:
 - 1. Type C-1: Equipment with large variations in the operating and installed weight (such as chillers, boilers, etc.), and equipment exposed to the wind (such as cooling towers, roof mounted fans and roof mounted air handling equipment), shall be mounted on spring mountings, similar to Type B, including the neoprene acoustical pad within a rigid sided housing that includes vertical limit stops and seismic restraints to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed, without changing the installed and operating heights. Restraining bolts shall have neoprene bushing between the bolt and the housing. Clearance around restraining bolts and between the spring assembly and the housing shall be a minimum of 0.5 inch to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation. Cooling tower mounts shall be located between the supporting steel and the roof or the grillage and dunnage when there is no provision for direct mounting. Mountings used outdoors shall be hot dipped galvanized with plated hardware. Provide height saving brackets as required. Mountings shall be equal to Type SLR as manufactured by Mason Industries, Inc.
 - 2. Type C-2: For seismically restrained equipment not subjected to wind loads or large variations in weight due to contained water, etc. Isolator shall be completely housed with ductile iron or steel housing to provide all-directional seismic snubbing. Isolator shall be complete with spring similar to Type B specified above. Isolator shall be complete with neoprene cup under spring base, all-directional neoprene snubbers, adjustable upward rebound plate and steel base with bolt holes. The snubber shall be adjustable vertically and allow a maximum of 1/4 inch travel in all directions before contacting the resilient snubbing collars. Mountings shall be equal to Type SSLFH as manufactured by Mason Industries, Inc.
- D. Type D: Neoprene-Spring Hangers: Spring and double deflection hangers of rigid steel frames containing minimum 1-1/4 inch thick neoprene elements at the top and a steel spring with general characteristics of Type B seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers or the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall

include a hanger drawing showing the 30 degree capability. Neoprene element shall have a minimum deflection of 0.35 inches. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Hangers shall be equal to Type 30N as manufactured by Mason Industries, Inc.

- E. Type D-RW: Neoprene-Spring Hangers with Seismic Rebound Washer: Type D-RW similar to Type D, but includes combination rubber and steel rebound washer as the seismic upstop. Rubber thickness shall be minimum 1/4 inch. Hangers shall be equal to Type RW30N as manufactured by Mason Industries, Inc.
- F. Type E: Precompressed Neoprene-Spring Hangers: Similar to Type D, but they shall be pre-compressed and locked at the rated deflection by means of a resilient upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30 degree capability. Hangers shall be equal to Type PC30N as manufactured by Mason Industries, Inc.
- G. Type E-RW: Precompressed Neoprene-Spring Hangers with Seismic Rebound Washer: Similar to Type E, but includes combination rubber and steel rebound washer as the seismic upstop. Rubber thickness shall be minimum 1/4 inch. Hangers shall be equal to Type PC30NS as manufactured by Mason Industries, Inc.
- H. Type G: Structural Steel Base: Base shall be of configuration complying with equipment manufacturer's recommended dimensions. Perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 inch provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in mounting locations to provide a base clearance of 1 inch. Bases shall be equal to Type WF as manufactured by Mason Industries, Inc. Isolators shall be as Scheduled.
- I. Type J: Isolators with Floating Concrete Foundation: Base shall be of configuration complying with equipment manufacturer's recommended dimensions and shall be large enough to support motors and suction and discharge pipe elbow supports. Floating foundation shall be constructed of steel channels and reinforced concrete. Materials shall comply to ASTM A36. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 inch. The base depth need not exceed 12 inch unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2 inch bars welded in place on 6 inch centers running both ways in a layer 1-1/2 inch above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in mounting locations to maintain a 1 inch clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Size frame as indicated on drawings or, if not shown, so that weight of frame plus concrete fill is greater than operating weight of equipment supported. Provide means for anchoring equipment to pad. Provide welded support brackets for connection to vibration isolators. Base shall be equal to Type K as manufactured by Mason Industries, Inc. Isolators shall be as scheduled. See Section 230500 for concrete for inertia bases.
- J. Type RC: Spring Isolation Roof Curb: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4 inch thick. Steel springs shall be laterally stable and rest on 1/4 inch thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust-resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring

locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 inch of insulation. Curb shall be equal to Type RSC as manufactured by Mason Industries, Inc.

- K. Type W: Neoprene Waffle Pads: For installations having light eccentric loading requiring only minimum isolation. Two (2) layers of 3/4 inch thick bridge bearing neoprene pad consisting of 2 inch square waffle modules separated horizontally by a 16 gauge galvanized shim, Type WSW as manufactured by Mason Industries, Inc. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc. When anchor bolts are not required, units shall have friction pads on both the top and bottom, equal to Type WMSW as manufactured by Mason Industries, Inc. When anchor bolts are required, units shall have a friction pad on the bottom with through holes for anchor bolts, equal to Type MBSW as manufactured by Mason Industries, Inc.
- L. Type WBR: Neoprene Captive Isolators: For installations having light eccentric loading requiring only minimal isolation. Mountings shall have a minimum 1.0 horizontal G rating. Mountings shall have bolts for rigid attachment to equipment and adequate base bolting provisions. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 inch and all-directional seismic capability. The mount shall consist of a ductile iron casting or steel containing two (2) separated and opposing molded neoprene elements. Mountings used inside shall be of ductile iron casting or steel. Mountings used outside shall be hot dipped galvanized with plated hardware. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. Mountings shall be equal to Type BR as manufactured by Mason Industries, Inc.
- M. Type Z: Neoprene Bushings and Washers: Equipment that is not externally isolated shall be provided with seismic neoprene bushings and washers at anchor bolt locations. Bushings and washers shall be made of neoprene to match mounting hole and anchor bolt diameter; redrill factory bolthole, if required. Anchors and equipment support boltholes must line up accurately. In order to isolate the anchor bolts from the equipment supports, a hole a minimum of 1/4 inch larger than the anchor bolt diameter shall be provided in the equipment support. A neoprene bushing of correct size shall be placed in the oversized hole. The bushing shall fill the space between the oversized hole and the bolt to prevent metal-to-metal contact. A flat washer and slightly larger neoprene washer shall be placed on the bolt prior to inserting into the equipment support bolthole. After aligning anchor bolts they shall be tightened to 80 percent of the allowable torque value indicated in the "Machinery Handbook" for the anchor bolt. Bushings shall be Type HG as manufactured by Mason Industries, Inc.

2.5 SEISMIC SNUBBERS

- A. Seismic snubbers shall be designed and adjusted to prevent contact during normal operation, while providing limits to excursion of isolated equipment during seismic activity.
- B. Vibration-isolated equipment shall be mounted on rigid steel frames or concrete bases. Vibration-isolated, floor-mounted equipment shall have isolators with integral snubbers or all-directional seismic snubbers that are double acting located adjacent to isolators as required to facilitate attachment to equipment frame or base and building structure.
- C. Snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials or one-piece molded neoprene bushing. Elastomeric materials shall be replaceable and minimum 3/4 inch thick.
- D. Snubbers shall be manufactured with air gap between hard and resilient materials of not less than 0.125 inch nor more than 0.25 inch. Snubbers shall be installed with factory set clearances. Capacity at 0.375 inch deflection shall be 3 to 4 times the load assigned to the mount grouping in its immediate area.
- E. Equipment shall be installed to resist seismic forces using isolators with integral snubbers, individual seismic snubbers similar to Mason Industries, Inc. Z1011 or Z1225 or a combination of both as directed by the manufacturer's registered engineer. Where equipment is isolated using neoprene isolators without the use of springs, Mason Industries, Inc. Type BR captive

mounting isolators may be used in lieu of standard neoprene isolators and separate snubbers. Anchors to structure shall be capable of withstanding seismic forces developed in restraint or snubber.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install vibration control and seismic bracing in accordance with Building Code stated in PART 1 of this Section, approved component manufacturer's certified submittal data, and this specification.
- B. Install anchors and anchor bolts fastened to the building structure and/or concrete housekeeping pad capable of withstanding the dynamic seismic loads developed in the seismic restraint. Provide anchorage of seismic restraints as detailed by seismic restraint manufacturer.
- C. Do not make rigid connections between equipment and the building structure that degrade the vibration isolation specified.
- D. Do not cause any change of position of equipment, piping, ductwork or controls resulting in stresses or misalignment.
- E. Coordinate work with other trades to avoid rigid contact with the building.
- F. Prior to installation, bring to the Architect/Engineer's attention any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions. Provide corrective work necessitated by conflicts after installation.
- G. Prior to installation bring to the Architects/Engineer's attention any discrepancies between the specifications and the field conditions. Provide corrective work necessitated by discrepancies after installation.
- H. Correct, at no additional cost, installations which are deemed defective in workmanship and materials.
- I. Positively attach seismic restraints to the equipment or system.
- J. Do not install seismic (transverse or longitudinal) bracing cable in the same direction as solid bracing on any run for a mechanical system.
- K. Do not brace a mechanical system to two (2) different parts of a building (e.g. wall and floor) at the same location since different parts of the building may act differently during an earthquake.
- L. Install seismic bracing cable such that the only visible slack is that due to the cable sag. Do not install the seismic support cables to support gravity loads.
- M. Install seismic bracing cables so they do not bend across edges of adjacent equipment or building structure.
- N. Install seismic restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
- O. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- P. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- Q. Make connections to building structure with a non-friction connection.
- R. Provide anchorage to equipment, systems and the building structure in accordance with vibration isolation and seismic restraint manufacturer's approved submittals.
- S. If piping, ductwork or suspended equipment is specified to be supported with vibration isolation hangers, provide cable sway bracing only.

3.2 SEISMIC REQUIREMENTS

- A. Install equipment, whether or not isolated, to resist seismic forces using isolators with integral snubbers, separate Mason Industries, Inc. Z1011 or Z1025 snubbers or bolted restraints as applicable. Equipment that is bolted to floors or pads without isolators shall be provided with oversized boltholes in equipment base or frame. Provide bolts with a neoprene bushing (specification Type Z) installed over the bolt shank to absorb shock generated by lateral impact resulting from seismic action. Provide anchors to building structure capable of withstanding seismic forces developed in the restraint, snubber, or equipment. Allowable service loads on embedded bolts shall conform to requirements of Building Code stated in PART 1 of this Section.
- B. Applications:
 - 1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction.
 - 2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on approved component manufacturer's certified submittal data to receive them and where required to prevent buckling of hanger rods due to seismic forces.
 - 3. Strength of Support and Seismic Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.
 - 4. Provide ductwork reinforcement and pipe hanger reinforcement at seismic restraints.
- C. Vibration Control and Seismic Restraint Device Installation:
 - 1. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
 - 2. Equipment Restraints:
 - a. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - c. Install seismic restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
 - 3. Piping Restraints:
 - a. Comply with requirements in MSS SP-127.
 - b. Space lateral supports a maximum of 40 ft. o.c., and longitudinal supports a maximum of 80 ft. o.c.
 - c. Brace a change of direction longer than 12 ft.
 - d. Provide reinforced clevis hangers at seismic restraints.
 - 4. Install cables so they do not bend across edges of adjacent equipment or building structure.
 - 5. Install seismic restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
 - 6. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
 - 7. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
 - 8. Drilled-in Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during

- coring or drilling. Notify the Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - f. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.
- D. Install seismic restraints so that no direct restraint forces are imparted on fan housings, vent sets, cooling towers and similar items not capable of withstanding seismic loading. Solidly attach this type equipment to steel frames, rails and bases arranged to absorb seismic forces. Install snubbers in conjunction with isolators and set no sooner than 2 weeks after isolators have been in place to allow for spring creep.
- E. Adjusting:
- 1. Adjust vibration isolators after piping system is at operating weight.
 - 2. Adjust limit stops on restrained spring vibration isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
 - 3. Adjust active height of spring vibration isolators.
 - 4. Adjust leveling devices as required to distribute loading uniformly on vibration isolators.
 - 5. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 230600 for piping flexible connections.

3.4 INSPECTION

- A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine equipment scheduled to be supported by vibration isolators for defects that adversely affect execution and quality of work.
- C. Examine vibration isolator, seismic restraints, and attachment hardware for defects.
- D. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- E. Report unsatisfactory conditions in writing to Engineer.
- F. Do not begin installation of vibration isolation and seismic restraints work until unsatisfactory conditions are corrected.

3.5 GENERAL INSTALLATION OF VIBRATION ISOLATORS FOR EQUIPMENT

- A. Install vibration isolators without causing change of position of equipment or piping which would result in stresses in piping connections or misalignment of shafts or bearings. Maintain equipment and piping in rigid position during installation. Do not transfer the load to isolator until installation is complete and the total operating weight of the equipment is available to bear on the isolators.
- B. Where no other base is required, support isolated equipment by attaching brackets directly to equipment. Attachment shall not cause any degradation of equipment.
- C. Provide brackets to accommodate vibration isolator and provide a mechanical stop. Isolator manufacturer shall specify the vertical position and size of bracket.
- D. Minimum operating clearance between base and pad or floor shall be 3/4 to 1-1/2 inch.
- E. Place base in position and support temporarily by using shims prior to installation of machine and base assembly.
- F. Install isolators without raising equipment and base assembly.
- G. After entire system installation is completed and under full operational load, adjust isolator so that load is transferred from shims to isolator. When isolators are properly adjusted, shims shall be barely free; remove shims.
- H. Lateral motion in excess of 1/4 inch during isolated equipment startup and shutdown shall be restrained by lateral spring-type mountings.

3.6 INSTALLATION OF SUSPENDED EQUIPMENT VIBRATION ISOLATORS

- A. Install isolators with isolator hanger box as close as possible to structure.
- B. Align hanger rods to clear hanger box, hanger box to be plumb and true.
- C. Load transfer isolators, when utilized, shall temporarily maintain load in rigid position until installation is complete and fully loaded.
- D. Overhead air handling units and fans shall be suspended by number of stems required, but in no case less than four (4) stems, with vibration isolators as scheduled.

3.7 INSTALLATION OF DUCTWORK VIBRATION ISOLATION

- A. Connect ducts to rotating equipment with flexible duct connections as specified in Section 238800.
- B. Provide isolation hangers for all ductwork within a distance of 50 ft. from the connected equipment and all ductwork within mechanical equipment rooms. Provide seismic bracing for ductwork and terminal boxes in accordance with SMACNA Guidelines and code requirements.

3.8 INSTALLATION OF PIPING VIBRATION ISOLATORS

- A. Connect pipes to vibration generating equipment with flexible pipe connectors as specified in Section 230600.
- B. For all piping described herein, provide resilient isolation from building structure. Provide floor-mounted supports with the same type of isolator or media as used for nearest isolated equipment connected to piping. Provide the hanger system with provision for piping to be held in place until connections are made and systems filled with water. Then release isolators to support weight. Provide springs supporting vertical risers with provisions for limit stops. In addition to the above, provide the following isolation:
 - 1. Piping 2 Inch and Larger: Provide isolation hangers for the first 50 ft. of piping from connected equipment and all piping within mechanical equipment rooms. Provide hangers with the same minimum static deflection as specified for the isolation mounts of the connected equipment. Provide resilient neoprene pipe wrap at rigid pipe hangers.

2. Piping Smaller Than 2 Inch: Provide minimum 1/2 inch thick resilient neoprene pipe wrap around piping at each rigid pipe hanger.
3. Provide seismic bracing for piping in accordance with code requirements.
4. Fire sprinkler piping is exempt from the vibration isolation procedures. Do not install equipment, hangers, isolators, or any other suspension apparatus that makes contact with the emergency fire sprinkler piping.

3.9 INSTALLATION OF SEISMIC ROOF CURB

- A. Install seismic roof curb in accordance with manufacturer's written installation instructions.
- B. Attach equipment to seismic roof curb to resist seismic and wind forces. Attachment shall not cause any degradation of equipment. Use galvanized hardware at attachments.
- C. Anchor or weld seismic roof curb to building roof structure to resist seismic and wind forces.

3.10 INSPECTION OF VIBRATION AND SEISMIC CONTROL

- A. Vibration and seismic restraint manufacturer or his representative shall examine the installation of mechanical equipment for the quality of work, missing supports or other defects that will adversely affect the vibration and seismic control systems. Examination shall include but not be limited to the following:
 1. Examine the installation of equipment to be supported by vibration isolators, hangers and any seismic restraints for missing supports and other defects.
 2. Examine the installation of ceiling mounted equipment and devices to be supported by hanger wires for missing hanger wires, ceiling clips, supports and other defects.
 3. Examine the installation of equipment/components support from building structure for quantity and type(s) of seismic restraints, and anchors and the flexible conduit connection.
 4. Examine the installation of floor or pad-mounted equipment for correct quantity and type vibration isolators, seismic restraints, anchors and anchor bolts.
 5. Examine the wall-mounted equipment for correct quantity and type seismic restraints and anchors.
 6. Measure vibration isolator restraint clearance.
 7. Measure vibration isolator deflection.
 8. Verify snubber minimum clearances.
 9. If a device fails test, modify installations of same type and retest until satisfactory results are achieved.
- B. Provide a written report from the vibration and seismic restraint manufacturer or manufacturer's representative indicating all unsatisfactory conditions to the Engineer.
- C. Provide a final inspection by the vibration and seismic restraint manufacturer or manufacturer's representative and submit written report to the Architect/Engineer certifying a correct installation, performance in compliance with approved submittal data.
- D. Do not continue installation work until unsatisfactory conditions are corrected.
- E. If Owner or his representative reports objectionable noise or vibration, arrange for field instrumentation testing and measurements by independent acoustical consultant to determine source, cause, and path of disturbance. At no additional cost, correct non-compliance with these specification requirements to the extent that noise or vibration can be attributed to vibration isolators or this portion of the work. Remove and replace malfunctioning devices and retest as specified above.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

3.11 VIBRATION SCHEDULE FOR MECHANICAL WORK

<u>Mark</u>	<u>Equipment or Installation</u>	<u>Design Deflection</u>	<u>Spec. Type</u>	<u>Notes</u>
Pump	In-line (Slab on Grade)	0.75	B, J	
Pump	In-line (20-30 ft span)	1.5	E	
AHU-1 to 5	AHU Supply Fan	2.0	B, G	2
ACCU	Air Cooled Condensing Units (Roof)	2.0	B	
ACCU	Air Cooled Condensing Units (Slab on Grade)	0.75	B	
CU	Condensing Units (Outdoors)	0.75	B	
CUH	Cabinet Unit Heater	0.75	D	
UH	Unit Heater	0.75	D	
KEF-1	Kitchen Exhaust Fan (Roof Mounted)	0.35	A	2
EF-1	Exhaust Fan (Roof Mounted)	0.35	A	2
EF-2	Relief Fan (Roof Mounted)	0.75	RC	
HEF-1	Hood Exhaust Fan (Roof Mounted)	1.50	RC	
-	Ductwork	0.75	D	1
-	Piping ≤ 3"	0.75	E	1
-	Piping > 3" and ≤ 6"	1.5	E	1
-	Piping > 6"	2.5	E	1

NOTES:

1. Provide spring hangers for ductwork and piping where indicated in this specification section.
2. Isolators to be provided internal to units; see Section 235000.

END OF SECTION 232400

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INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 232500 – MECHANICAL INSULATION

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL INSULATION REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	2
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
PART 2 - PRODUCTS		2
2.1	GENERAL	2
2.2	PIPE INSULATION MATERIALS	2
2.3	DUCTWORK INSULATION MATERIALS	3
2.4	EQUIPMENT INSULATION MATERIALS	5
2.5	NOISE CONTROL COVERING	5
2.6	EXISTING INSULATION	5
PART 3 - EXECUTION		5
3.1	GENERAL	5
3.2	METHOD OF APPLICATION (PIPING AND RELATED COMPONENTS)	6
3.3	METHOD OF APPLICATION (DUCTWORK)	7
3.4	METHOD OF APPLICATION (EQUIPMENT)	9
3.5	METHOD OF APPLICATION (NOISE CONTROL COVERING)	9
3.6	PIPE INSULATION SCHEDULE	9
3.7	DUCTWORK INSULATION SCHEDULE	10
3.8	EQUIPMENT INSULATION SCHEDULE	10

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SECTION 232500 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and all requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to the work under this specification section.

1.2 GENERAL INSULATION REQUIREMENTS

- A. Contractor shall be responsible for insulating all work installed under his contract. For equipment furnished by others but installed under this contract, the cost of required insulation shall be included in the Contractor's proposal.
- B. Insulation work shall be performed by an insulation subcontractor whose name shall be submitted to the Architect/Engineer for approval prior to authorization for performance of the work.
- C. Other than factory-applied insulation, provide insulation materials installed indoors with composite (insulation, jacket or facing and adhesive used) fire and smoke hazard ratings as tested by procedure ASTM E-84, NFPA 255 and UL 723, not exceeding flame spread index of 25 and smoke developed index of 50. Provide insulation installed outdoors with fire and smoke hazard ratings not exceeding flame spread index of 75 and smoke developed index of 150. Treatment of facing or jackets applied to meet these requirements shall be permanent. Use of water-soluble treatments is prohibited.
- D. Insulation material and thickness shall meet the requirements of ASHRAE Standard 90.1-2007; insulation thickness shall be increased above the values shown in PART 3 of this section as required to satisfy the Standard.
- E. Apply insulation in strict accordance with insulation manufacturer's instructions using adhesives, materials and methods required to meet flame spread and smoke developed requirements. Installation shall be in conformance with the latest edition of the National Commercial and Industrial Insulation Standards Manual published by the Midwest Insulation Contractors Association (MICA).

1.3 SCOPE OF WORK

- A. This section of the specification is intended to cover all insulation required under Division 23 HVAC work, i.e., to cover all hot and cold surfaces to reduce energy losses, to provide personnel protection due to high-surface temperatures, and to provide a vapor barrier for cold surfaces to prevent condensation. See also Section 230100 - BASIC MECHANICAL REQUIREMENTS.

1.4 DESCRIPTION OF SYSTEMS

- A. The basic insulation system for this project consists of fiberglass insulation for pipe, ductwork and equipment with suitable jacketing to protect the insulation and to provide an adequate vapor barrier.
- B. Where surface temperatures are above those encountered with typical HVAC services, calcium silicate insulations with appropriate jacketing are specified.
- C. Removable insulation systems are specified and shall be used for equipment and piping components that require routine service. Flexible elastomeric, closed-cell insulation may be used for removable sections where service conditions do not exceed the manufacturer's published limits.

1.5 SUBSTITUTIONS

- A. No substitutions will be allowed except as specified in Section 230100 - BASIC MECHANICAL REQUIREMENTS.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Comply with Section 230100.
- B. Submit material product data for each type of product. Include thermal conductivity, water-vapor permeability, and jackets.
- C. Submit an insulation schedule indicating insulation material, thickness and jacket type for each size range of each service.
- D. LEED Submittal:
 - 1. Product Data for Credit IEQ 4.1: For adhesives, sealants and sealant primers, including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Comply with requirements in the "Pipe Insulation Schedule," "Ductwork Insulation Schedule," and "Equipment Insulation Schedule" articles for application of insulating materials.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Volatile Organic Compound (VOC) Content of Adhesives, Sealants, and Sealant Primers: Provide products that comply with the VOC limits as listed in South Coast Air Quality Management District (SCAQMD) Rule #1168, effective date July 1, 2005 and rule amendment date of January 7, 2005.

2.2 PIPE INSULATION MATERIALS

- A. Fiberglass Insulation: Provide insulation composed of inorganic glass fibers bonded with a thermosetting resin. Fiberglass insulating materials shall be manufactured by Owens-Corning. Insulating materials by Johns Manville or Knauf meeting these specifications will be considered for approval. The maximum thermal conductivity in accordance with ASTM C 335 shall be as follows:

Maximum Thermal Conductivity (Btu-in/hr-sq.ft.-deg. F.)	Mean Rating Temperature (deg. F.)
0.34	250
0.31	200
0.30	150
0.28	100

- 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1 with factory-applied jacket.
- 2. Blanket Insulation: Comply with ASTM C 553, Type II with factory-applied jacket.

- B. Flexible Elastomeric Insulation: Provide insulation composed of closed-cell, self-sealing, expanded rubber material. Comply with ASTM C 534, Type I for tubular materials and Type II

for sheet materials. The maximum thermal conductivity shall be 0.27 Btu-in/hr-sq.ft.-deg. F. at a mean temperature rating of 75 deg. F. Polyolefin insulation products are not acceptable. Insulating materials shall be manufactured by Aeroflex USA. Insulating materials by Armacell LLC or K-Flex USA meeting these specifications will be considered for approval.

1. Use only factory pre-slit insulation with factory applied adhesive seam seal. Do not use unslit insulation with field cut longitudinal slit; unslit insulation is only acceptable in short sections where the insulation can be applied over the piping without a longitudinal slit.
- C. Polyisocyanurate (Polyiso) Insulation: Provide preformed, rigid, cellular polyisocyanurate insulation with minimum 2.0 pcf density and intended for use as thermal insulation. Insulation shall be TRYMER 2000 XP as manufactured by ITW Insulation Systems. Insulating materials by Dyplast (ISO-25) or Elliott Company (Elfoam P200) meeting these specifications will be considered for approval.
1. Product shall meet the requirements of ASTM C591, Type IV, except maximum thermal conductivity shall be 0.19 Btu-in/hr-ft²-deg. F. at 75 deg. F. after 180 days of aging.
 2. Product shall have a flame spread/smoke generation performance tested in accordance with ASTM E-84 of 25/50 or better at thicknesses of 1 inch or less.
 3. Fabricate shapes according to ASTM C450 and ASTM C585.
 4. Vapor Retarder: Insulation shall be provided with a factory-applied vapor retarder. Joints shall be sealed with a vapor retarder tape. Vapor retarder shall have the following properties:
 - a. Thickness: 6 mils +/- 20 percent
 - b. Maximum Water Vapor Permeability in accordance with ASTM E96: 0.01 perm
 - c. Color: White
- D. Jacketing and Finishing:
1. Provide jacketing for all insulation. Unless otherwise specified, jacketing materials for fiberglass piping insulation shall be reinforced, all-service, vapor retarder jacket with self-sealing lap joint suitable for direct application of finish without surface preparations. Jacket permeance shall not exceed 0.02 perm using Procedure A of ASTM E 96.
 2. Prefabricated Thermal Insulating Fitting Covers: Provide 20 mil, high-impact, gloss white, UV-resistant, polyvinyl chloride fitting covers with fiberglass insulation inserts. Comply with ASTM D 1784, Class 16354-C. PVC fitting covers with inserts shall be rated for services from 0 deg. F. to 450 deg. F. The maximum thermal conductivity of the inserts shall be 0.34 Btu-in/hr-sq.ft.-deg. F. at a mean temperature rating of 150 deg. F. Where flexible elastomeric pipe insulation is used, fittings shall be covered the same as specified above using fitting covers.
 3. Provide additional PVC jacketing for all fiberglass pipe insulation within mechanical rooms. Provide 20 mil, high-impact, gloss white, UV-resistant, polyvinyl chloride roll jacketing. Provide factory-prefabricated fitting covers to match jacket. Comply with ASTM D 1784, Class 16354-C.
 4. For piping and equipment conveying cold or refrigerated liquids or air, provide insulation with vapor barrier jacket having vapor permeability rating suitable for the service intended; joints shall be properly sealed. Flexible elastomeric insulation will not require vapor barrier jacket.
 5. For insulation installed outdoors and insulation subject to water damage, provide an additional 0.016 inch aluminum jacket with lock seam, longitudinal joint and gasketed bands for butted joints as required for a watertight installation. Jacket shall be complete with waterproof, laminated paper lining and shall be manufactured by ITW Insulation System or RPR Products.

2.3 DUCTWORK INSULATION MATERIALS

- A. General: The minimum thermal resistance for insulation in conditioned spaces or return air plenums shall be R-3.3; the minimum thermal resistance for insulation in unconditioned or

heated only spaces shall be R-5.0. The minimum thermal resistance for exterior insulation shall be R-6.5. Thermal resistance shall be based on a mean temperature rating of 75 deg. F.

- B. **Fiberglass Insulation:** Provide insulation composed of inorganic glass fibers bonded with a thermosetting resin. Fiberglass insulating materials shall be manufactured by Owens-Corning. Insulating materials by Johns Manville, CertainTeed, or Knauf meeting these specifications will be considered for approval.
 - 1. **Board Insulation:** Provide 3.0 pcf, semi-rigid, fiberglass board insulation complying with ASTM C 612, Type IB. Provide with factory-applied foil reinforced kraft or all-service jacket vapor retarder facing.
 - 2. **Blanket Insulation:** Provide 1.0 pcf, fiberglass blanket insulation with factory-laminated reinforced foil/kraft vapor retarder facing. Comply with ASTM C 553, Type II.
- C. **Flexible Elastomeric Sheet Insulation:** Provide insulation composed of closed-cell, self-sealing, expanded rubber material complying with ASTM C 534, Type II for sheet materials. The maximum thermal conductivity shall be 0.27 Btu-in/hr-sq.ft.-deg. F. at a mean temperature rating of 75 deg. F. Polyolefin insulation products are not acceptable. Insulating materials shall be manufactured by Aeroflex USA. Insulating materials by Armacell LLC or K-Flex USA meeting these specifications will be considered for approval.
- D. **Fire-Rated Insulation Systems:** Provide high-temperature insulation systems rated for a zero clearance around ductwork to combustible materials. Provide firestop sealants, tape, insulation pins, clips, banding, and other components in accordance with manufacturer's instructions to maintain product listing and fire rating.
 - 1. **Fire-Rated Duct Wrap for Ventilation Ducts and Fume Exhaust Ducts:** Provide single layer fire resistant wrap consisting of a bio-soluble ceramic fiber blanket encapsulated with a scrim-reinforced foil. Provide system UL listed and tested according to ISO 6944 "Fire Resistance Tests – Ventilation Ducts" for 2-hour fire resistive rating. Provide one of the following products:
 - a. Fire Barrier Duct Wrap 615 by 3M
 - b. Flameshield VAD Blanket by ETS Schaefer
 - c. FireMaster FastWrap XL by Thermal Ceramics
 - d. FyreWrap EZ 1.5 Duct Insulation – VAD System by Unifrax
 - 2. **Fire-Rated Duct Wrap for Grease Exhaust Ducts:** Provide two-layer system consisting of non-asbestos, inorganic blanket encapsulated with scrim-reinforced foil. Provide rated access doors to maintain fire resistive rating. Provide system meeting all criteria of ASTM E 2336 "Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems" for 2-hour fire resistive rating. Provide one of the following products:
 - a. Fire Barrier Duct Wrap 15A by 3M
 - b. FireMaster FastWrap XL by Thermal Ceramics
 - c. FyreWrap Elite 1.5 Duct Insulation – Grease Duct System by Unifrax
- E. **Jacketing:**
 - 1. All fiberglass insulation shall be jacketed. Jackets for fiberglass insulation shall be ASJ or FRK as specified. Jacket permeance shall not exceed 0.02 perm using Procedure A of ASTM E 96.
 - 2. Flexible elastomeric, closed-cell insulation does not require vapor barrier jacket.
- F. **Ducts Exposed Outside Building:** Provide weather barrier mastic reinforced with resin-coated woven fiberglass mesh over fiberglass board insulation. Weather barrier mastic shall be water based, vinyl-acrylic mastic coating rated for -40 to 180 deg. F. service. Mastic shall be U.V. resistant. Mastic shall be Childers Vi-Cryl. Mesh shall be 10x10 leno weave, resin-coated fiberglass mesh. See PART 3 for additional requirements.

2.4 EQUIPMENT INSULATION MATERIALS

- A. General: The minimum R-value for insulation in conditioned spaces or return air plenums shall be 3.3; the minimum R-value for insulation in unconditioned or heated only spaces shall be 5.0. The minimum R-value for exterior insulation shall be 6.5. R-values shall be based on a mean temperature rating of 75 deg. F.
- B. Fiberglass Insulation: Provide insulation composed of inorganic glass fibers bonded with a thermosetting resin. Fiberglass insulating materials shall be manufactured by Owens-Corning. Insulating materials by Johns Manville, CertainTeed, or Knauf meeting these specifications will be considered for approval.
 - 1. Board Insulation: Provide 2.5 pcf, semi-rigid, fiberglass board insulation complying with ASTM C 1393, Type IIIA. Provide with factory-applied foil reinforced kraft or all-service jacket facings.
 - 2. Blanket Insulation: Provide 3.0 pcf, fiberglass blanket insulation complying with ASTM C 612, Type IB. Provide with factory-applied foil reinforced kraft or all-service jacket facings.
 - 3. Duct Liner Board: Provide 3.0 pcf, semi-rigid, fiberglass duct linerboard complying with ASTM C 1071. Surface shall be coated to prevent erosion and shall resist fungal and bacterial growth when subjected to ASTM G 21 and G 22 test methods.
- C. Flexible Elastomeric Sheet Insulation: Provide insulation composed of closed-cell expanded rubber material complying with ASTM C 534, Type II for sheet materials. Polyolefin insulation products are not acceptable. Insulating materials shall be manufactured by Aeroflex USA. Insulating materials by Armacell LLC or K-Flex USA meeting these specifications will be considered for approval.

2.5 NOISE CONTROL COVERING

- A. Sound Barrier: Provide a sound barrier composed of minimum 0.1 inch thick, mass-loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side. The barrier shall have a nominal density of 1.0 psf. The barrier shall have a rated service temperature range of -10 deg. F. to 180 deg. F. The barrier material shall have composite fire and smoke hazard ratings as tested by procedure ASTM E-84 not exceeding flame spread index of 25 and smoke developed index of 50.
- B. Decoupling Layer: Provide a 1 inch thick, scrim-faced, quilted fiberglass batting.
- C. Accessories: Provide adhesive tape and bands in accordance with manufacturer's installation instructions.
- D. Sound Performance: Provide noise control covering with minimum STC rating of 28 when tested as a free-hanging barrier in accordance with ASTM E90.
- E. Manufacturer: Provide Model KNM-100ALQ by Kinetics or Model B-10LAG/QFA-3 by Sound Seal.

2.6 EXISTING INSULATION

- A. For existing insulation damaged due to work under this contract, patch or replace with similar insulation. Where such patching occurs in exposed areas, finish insulation to match existing.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install insulation after ductwork, pipes and vessels have been tested. Provide continuous insulation, extending full thickness through sleeves. Size pipe sleeves to accommodate the specified insulation thickness.
- B. Install insulation in accordance with applicable codes and ordinances.

- C. For additional details of installing insulating material, refer to appropriate paragraphs of PART 2 of this specification section and the National Commercial & Industrial Insulation Standards Manual published by the Midwest Insulation Contractors Association (MICA).

3.2 METHOD OF APPLICATION (PIPING AND RELATED COMPONENTS)

A. General:

1. Install all insulation in accordance with National Insulation Standards published by Midwest Insulation Contractors Association (MICA).
2. Seal exposed edges of insulation with vapor barrier mastic.
3. The following piping exposed outside the building or located in unheated building areas will be electrically traced prior to application of insulation:
 - a. Condenser water
 - b. Makeup water
 - c. Below grade fuel oil

- B. Flexible Elastomeric Insulation: Install insulation by sealing longitudinal joints and by using tape on joints between sections and at fittings and valves.

C. Flanges:

1. On Hot Piping (below 260 deg. F., such as Hot Water, Low-Pressure Steam, etc.): Stop insulation at flanges to allow access to bolts. Finish ends of insulation.
2. On High-Temperature Piping (260 deg. F. or Higher, such as High-Pressure Steam or High-Temperature Water, etc.): Insulate flanges and mechanical couplings similar to pipe and fittings.
3. On Low-Temperature Piping (such as Chilled Water, etc.): Stop insulation at flanges and mechanical couplings. Seal ends of insulation. Cover flanges with 1/2 inch flexible elastomeric, closed-cell, removable insulation slipcover, stretched over flanges and fitted snugly against piping insulation forming tight vapor seal.

D. Pipe Saddles:

1. Do not rest insulation directly on pipe supports except under the following conditions:
 - a. Flexible foamed, plastic type insulation for pipes 1 inch and smaller.
 - b. Rigid elastomeric, closed-cell type insulation for pipes 2-1/2 inch and smaller and not subject to thermal expansion or contraction.
2. Hot Piping (Hot Water, Steam, etc.):
 - a. When piping 2-1/2 inch and smaller is directly supported by pipe hangers, fit insulation around hangers and finish in a similar manner as specified for fittings. For larger piping, use Pipe Shields Incorporated hanger shields, consisting of galvanized steel jacket sized to completely circumvent piping and insulation insert of calcium silicate of same insulation thickness as the specified insulation. Shop-fabricated insulation shield may be submitted for approval in lieu of using factory-fabricated shield.
 - b. When roller hangers support piping, install pipe covering protection saddles, Anvil International Series 160-166 or approved equal.
3. Cold Piping (Chilled Water, etc.):
 - a. Provide insulation on cold piping passing uninterrupted through pipe hangers.
 - b. At hangers, provide insulation saddles by Pipe Shields Incorporated consisting of galvanized steel saddle with insert of calcium silicate insulation. Insulation insert shall be of adequate density to support pipe and contents without deformation. Similar shop-fabricated saddles may be used at Contractor's option but shall be submitted to the Architect/Engineer for approval prior to installation.

- E. Insulate fittings with premolded or built-up insulation of equal insulation value and vapor barrier as piping insulation. Finish fitting insulation with jacket equal to the jacket of adjoining pipe

insulation. Fitting covers with fiberglass insulation inserts may be used for services from 0 deg. F. to 450 deg. F. Seal insulation at joints and at connection to adjacent insulation with tape and vapor barrier cement.

- F. Strainers: Insulate strainer bodies for low-pressure steam and water services as specified for valve bodies. Insulate removable portion of strainers with flexible elastomeric, closed-cell insulation held in place with stainless steel bands.
- G. Expansion Joints and Flexible Connectors: Regardless of insulation type used on piping, for expansion joints and flexible connectors which are subject to condensation, below 65 deg. F. or to temperatures above 120 deg. F. and up to 220 deg. F. cover with 1/2 inch thick, flexible elastomeric, closed-cell insulation lapped over ends of adjacent pipe insulation and seal with aluminum or stainless steel pressure bands installed at both ends of joint over lapped portions of insulation.
- H. Valves:
 - 1. Insulate valve bodies for low-temperature service, such as chilled water, with premolded fiberglass of insulating and vapor permeability value equal to adjoining pipe insulation. Finish insulation with two (2) coats of vapor barrier mastic, reinforced with glass fabric extending 2 inch over adjacent pipe insulation. At Contractor's option, flexible elastomeric, closed-cell insulation may be used and shall be cut and mitered to fit valve body. Seal elastomeric insulation at joints and at connection to adjacent insulating materials with tape and vapor barrier cement.
 - 2. Valve bodies on hot piping at temperatures below 260 deg. F. do not require insulation.
 - 3. Insulate valve bodies on high-temperature lines at 260 deg. F. or above to same insulating value as adjoining pipe with mitered pipe insulation wired in place and finished with glass fabric jacket and asbestos-free insulating cement. Mitered insulation shall be fiberglass up to operating temperature of 450 deg. F. and shall be asbestos-free, calcium silicate for operating temperatures above 450 deg. F. At Contractor's option, valves may be insulated with asbestos-free, insulating cement and covered with glass fabric jacket.
- I. Accessories:
 - 1. Insulate accessories and specialties, such as thermometer wells, pressure gauge tappings and strainers on low-temperature piping systems, e.g., chilled water with 3/8 inch thick flexible elastomeric, closed-cell insulation material. Seal ends with vapor barrier mastic cement.
 - 2. Ensure that insulation for removable components is easily removable without disturbing the main piping insulation.

3.3 METHOD OF APPLICATION (DUCTWORK)

- A. General: Cover surfaces shall be covered with specified thickness of insulation, including but not limited to, flanges and hangers in contact with ducts. Install all insulation in accordance with National Insulation Standards as published by Midwest Insulation Contractors Association (MICA). Install insulation only after ducts have been tested.
- B. Installation of Blanket Type Duct Insulation:
 - 1. Apply insulation with adhesive around entire perimeter of duct in 6 inch wide strips on 12 inch centers.
 - 2. For rectangular ducts, 24 inch and larger in any direction, additionally secure the insulation to bottom of ducts with mechanical fasteners spaced on 18 inch centers and not more than 18 inch from the duct corners. Avoid sagging of insulation.
 - 3. Provide mechanical fasteners on sides of duct risers spaced on 18 inch centers and not more than 18 inch from duct corners.
 - 4. Impale insulation on mechanical fasteners and press thoroughly into adhesive. Ensure joints in vapor barrier jacket overlap 2 inch. Do not compress insulation to a thickness less than that specified.
 - 5. Install insulation continuous over standing seams and trapeze type duct hangers.

6. Install speed washers where mechanical fasteners are used. Trim pins back to the washers.
7. Secure jacket overlaps with adhesive and staple on 4 inch centers.
8. Apply vapor barrier coating to staples and seams.
9. Cover breaks in jacket material with patches of same material as vapor barrier. Extend patches not less than 2 inch beyond break or penetration in all directions and secure with brush coat of vapor barrier coating.
10. At jacket penetrations, such as hangers, thermometers and damper operating rods, fill the voids in the insulation with vapor barrier coating and seal the penetrations with a brush coat of vapor barrier coating.
11. Seal insulation terminations and pin punctures and flash with reinforced vapor barrier coating by applying two (2) coats of vapor barrier coating with glass cloth embedded between coats. The coating shall have dry film thickness of approximately 1/16 inch and shall overlap adjoining insulation and uninsulated surface by 2 inch.

C. Installation of Board Type Duct Insulation:

1. Secure rigid insulation to duct by the use of adhesive applied to four (4) sides in 6 inch wide strips, 12 inch on center. Provide mechanical fasteners on all four (4) sides of duct, spaced not more than 12 inch apart and not more than 3 inch from edges of insulation joints. Provide a minimum of two (2) rows of fasteners for each side of duct 12 inch and larger. Provide one row for each side of ducts with dimensions less than 12 inch.
2. Form duct insulation with minimum jacket seams, and do not allow a jacket seam on or within 3 inch of duct corner. Bring insulation up to standing seams, reinforcing and other vertical projections; edges shall be sealed with vapor barrier cement. Provide a band of insulation circumventing the vertical projection and overlapping adjacent insulation by a minimum of 1 inch on all sides. Provide insulating band of same material and thickness as duct insulation and cover with vapor barrier coating, overlapped and sealed to adjacent duct insulation.
3. Impale insulation on fasteners, install speed washers, and trim pins to washers.
4. Seal joints in insulation jacket with a 4 inch wide strip of the same material as the vapor barrier jacket. Secure the strip with adhesive and staple.
5. Seal staples and seams with a brush coat of vapor barrier coating.
6. At jacket penetrations, such as hangers, thermometers and damper operating rods, fill voids in insulation with vapor barrier coating, and seal penetrations with a brush coat of vapor barrier coating.
7. Seal insulation terminations and pin punctures and flash with reinforced vapor barrier coating. Apply two (2) coats of vapor barrier coating with glass cloth embedded between coats. The coating shall have dry film thickness of approximately 1/16 inch and shall overlap adjoining insulation and uninsulated surface by 2 inch.
8. For ductwork exposed outside the building, slope horizontal insulation at least 1/2 inch per foot to prevent ponding water. Apply weather barrier mastic reinforced with fiberglass mesh. The coating shall have a minimum dry film thickness of the 1/16 inch.

D. Installation of Fire-Rated Insulation Systems:

1. Install duct wrap system in accordance with manufacturer's instructions and recommendations. Each duct shall be individually fireproofed.
2. Install duct wrap in direct contact with the duct it encloses.
3. For grease duct applications, protect every portion of duct with no less than two (2) layers of insulation. Provide three (3) layers of duct wrap to protect cleanouts on grease duct system. See details for installing cleanouts in manufacturer's printed materials.
4. At floor and wall penetrations, maintain the required rating when using duct wrap by having a continuous sum of duct wrap through the opening.

3.4 METHOD OF APPLICATION (EQUIPMENT)

- A. Chilled Water Pumps: Insulate entire pump casing, except lubrication fittings, with elastomeric insulation material of basket construction. Hold basket in place with stainless steel bands or plastic tape for ease of removal. Apply two (2) coats of Armaflex or approved equal finish.

3.5 METHOD OF APPLICATION (NOISE CONTROL COVERING)

- A. Install noise control covering in accordance with manufacturer's instructions and recommendations.
- B. Ensure that the outer surface of the pipe or duct is clean and free of dust, dirt or similar foreign matter.
- C. Cut and apply the insulation decoupling layer. Obtain a uniform thickness by butting all seams together; do not overlap joints. At elbows and other fittings, field measure and miter cut the insulation to fit. Temporarily fasten the insulation in place, but ensure that the insulation is not compressed by the fasteners.
- D. Wrap the noise barrier around the insulation decoupling layer. Overlap each joint in the barrier with a minimum 2 inch wide strip of barrier material and adhere using adhesive.
- E. Provide bands around the barrier on either side of all radial seams and at the midpoint of all barrier sections longer than 24 inches.

3.6 PIPE INSULATION SCHEDULE

Service	Design Temp deg. F.	Insulation Material	Pipe Size inch	Insulation Thickness inch	Jacket Required	Notes
Chilled Water	40-60	Polyiso	All	1	Yes	
Heating Hot Water	75-200	Fiberglass	≥4	1-1/2		
			<4	1		
Air Terminal Unit Coil Pipe Bends	-	Elastomeric	All	1/2	No	
Condensate Drains	-	Elastomeric	All	1/2	No	1
Refrigerant Lines	40-60	Elastomeric	All	1	No	2
Makeup Water (in Heated Areas)	-	Elastomeric	All	1/2	No	
Makeup Water (in Unheated Areas or Outside the Building)	-	Fiberglass	All	1-1/2	Yes	
Glycol Heat Recovery Loop	30-100	Elastomeric	All	1	No	

NOTES:

1. In spaces used as supply or return air plenum, provide 1/2 inch fiberglass with jacket.
2. Provide two (2) layers of 1/2 inch insulation with staggered joints.

3.7 DUCTWORK INSULATION SCHEDULE

Service	Insulation Material	Insulation Thickness inch	Jacket Required	Notes
Outside Air Ducts and Plenums	Fiberglass Board	1	Yes	
Relief Air and Exhaust Air Plenums	Fiberglass Board	1	Yes	
Relief Air and Exhaust Air Ducts from Plenum to Backdraft/Motorized Damper	Fiberglass Board	1	Yes	
Mixed Air and Prefilter Plenums	Fiberglass Board	1	Yes	
Medium-Pressure Class, Single Wall Ducts (Rectangular, Round)	Fiberglass Blanket	1-1/2	Yes	
Medium-Pressure Class, Field-Fabricated Discharge Transitions	Fiberglass Board	1	Yes	
Fume Exhaust Ducts (where fire rating is required)	Duct Wrap	1-1/2	Yes	
Kitchen Hood (Grease) Exhaust Duct (Where Fire Rating is Required)	Duct Wrap	3	Yes	1
	Rigid Board	3	Yes	

NOTES:

1. Provide two (2) layers of 1-1/2 thick duct wrap insulation.

3.8 EQUIPMENT INSULATION SCHEDULE

Service	Insulation Material	Insulation Thickness inch	Jacket Required	Notes
Field-Fabricated Air Handling Unit Sections and Transition Pieces	Duct Liner Board	1	No	
Airflow and Static Pressure Measuring Stations	Fiberglass Board	1	Yes	
Sound Traps	Fiberglass Board	1	Yes	
Chilled Water Pumps	Elastomeric	3/4	No	
Air Separator (Chilled Water)	Elastomeric	1/2	No	
Air Separator (Heating)	Fiberglass Blanket	2	Yes	1

NOTES:

1. Components that must be accessed for service, insulate with fiberglass board insulation or pipe insulation, or combination of both as applicable.

INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 235000 – HAC EQUIPMENT

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCE	1
1.2	EQUIPMENT REQUIREMENTS	1
1.3	SCOPE OF WORK	2
1.4	SUBSTITUTIONS	2
1.5	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
PART 2 - PRODUCTS		2
2.1	AIR HANDLING UNIT (MODULAR)	2
2.2	HEAT TRANSFER COILS	3
2.3	AIR FILTERS	4
2.4	MODULAR BOILER	5
2.5	LOW TEMPERATURE BOILER VENTS	7
2.6	VARIABLE FREQUENCY DRIVES (VFD)	8
2.7	DUCTLESS SPLIT COOLING SYSTEM	12
2.8	LABORATORY EXHAUST FANS (MIXED FLOW, INDUCED DILUTION TYPE)	14
2.9	IN-LINE CENTRIFUGAL FANS	16
2.10	CEILING-MOUNTED EXHAUST FAN	17
2.11	CENTRIFUGAL UPBLAST ROOF EXHAUST FAN	17
2.12	PUMPS (IN-LINE)	19
2.13	PROPELLER UNIT HEATERS	19
2.14	CABINET UNIT HEATERS	20
2.15	FINNED TUBE RADIATION	21
2.16	PLATE HEAT EXCHANGER	22
2.17	GLYCOL SOLUTION AND PUMP PACKAGE	22
2.18	CHEMICAL FEEDERS	23
PART 3 - EXECUTION		23
3.1	INSTALLATION OF AIR HANDLING UNIT (MODULAR)	23
3.2	INSTALLATION OF MODULAR BOILER	24
3.3	INSTALLATION OF LOW TEMPERATURE STACK	25
3.4	INSTALLATION OF VARIABLE FREQUENCY DRIVES (VFD)	25
3.5	INSTALLATION OF DUCTLESS SPLIT COOLING SYSTEM	25
3.6	INSTALLATION OF LABORATORY EXHAUST FANS (MIXED FLOW, INDUCED DILUTION TYPE)	26
3.7	INSTALLATION OF IN-LINE CENTRIFUGAL FANS	27
3.8	INSTALLATION OF CEILING-MOUNTED EXHAUST FAN	27
3.9	INSTALLATION OF CENTRIFUGAL UPBLAST ROOF EXHAUST FAN	28
3.10	INSTALLATION OF PUMPS (IN-LINE)	29
3.11	INSTALLATION OF PROPELLER UNIT HEATERS	30
3.12	INSTALLATION OF CABINET UNIT HEATERS	31
3.13	INSTALLATION OF FIN TUBE RADIATION	31
3.14	INSTALLATION OF PLATE HEAT EXCHANGER	31
3.15	INSTALLATION OF GLYCOL SOLUTION AND PUMP PACKAGE	32
3.16	INSTALLATION OF CHEMICAL FEEDERS	32

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SECTION 235000 - HAC EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCE

- A. Sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to work under this specification section.

1.2 EQUIPMENT REQUIREMENTS

- A. General: Equipment shall be installed in accordance with applicable sections of this specification and shall be complete in every respect, including necessary accessories required to complete systems. Equipment shall meet all applicable codes and shall be UL listed when required by code or local authorities.
- B. Prewired Control Panels (PWCP): Each piece of equipment required by these specifications or the Equipment Data Schedule to have a prewired control panel shall have panels that contain but are not limited to the following:
 - 1. NEMA enclosure with hinged door or doors and gaskets, louvers, fans and durable finish to match the environment where it is located.
 - 2. Power input terminals of correct size to match conductors indicated on the Equipment Data Schedule on the drawings.
 - 3. Control power transformer with primary and secondary fuses.
 - 4. Pushbuttons, switches, liquid crystal display (LCD), and LED or pilot lights to indicate ON, OFF, speed or other appropriate information as specified for each piece of equipment.
 - 5. Wiring diagram on the inside cover indicating terminals by number, wiring color to each control device both inside the panel and remote. Diagram shall be covered in plastic and affixed to the inside cover or box in a location easily readable after opening the front cover plate.
 - 6. Panel shall contain motor starter as applicable for specific equipment to provide a complete and working system.
 - 7. Individual equipment sections of this specification contain additional prewired control panel requirements. Read each section for requirements.
- C. Filters:
 - 1. Construction Filters:
 - a. HAC shall provide temporary filters in all air systems and change these filters through out the duration of construction to maintain a clean air system. When construction is taking place in a given area or floor and the air system serving this area or floor also serves other areas not within the project boundaries, localized temporary filters shall be installed in the return path as it exits the construction zone or at all return air grilles.
 - b. Temporary filter media shall have a Minimum Efficiency Reporting Value (MERV) 8 as determined by ASHRAE 52.2.
 - 2. Occupancy Filters:
 - a. Upon completion of construction HAC shall install one set of clean filters in each location of each air system. Filters shall be of the type specified for that specific piece of equipment.
 - b. HAC shall provide filter media for final occupancy meeting a Minimum Efficiency Reporting Value (MERV) 13 as determined by ASHRAE 52.2. in all air systems.
 - 3. Equipment shall not be operated at anytime without filters in place.

1.3 SCOPE OF WORK

- A. This section of the specifications covers detailed requirements of heating and air conditioning equipment required for proper operation of heating, cooling, refrigeration and ventilating systems.

1.4 SUBSTITUTIONS

- A. No substitutions will be allowed except as specified under Section 230100, BASIC MECHANICAL REQUIREMENTS.

1.5 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 230100.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT (MODULAR)

- A. General: Provide single zone, draw-through type air handling unit as indicated on the drawings and as scheduled in accordance with the following specifications. Units shall be ARI rated.
- B. Construction:
 - 1. Casings: Panels shall be double wall, 2 inch thick panels fabricated of galvanized steel with enamel finish. The unit shall be constructed as a complete frame with removable panels. Removal of side panels shall not affect the structural integrity of the unit. The casing shall be able to withstand up to 6 inches w.g. positive or 4 inches w.g. negative static pressure. All exterior wall panels shall be made of galvanized steel. Closed-cell foam gasketing shall be provided where modules join to prevent air leakage. Modules shall be factory-insulated. Insulation and insulation adhesive shall comply with NFPA-90A requirements for flame spread and smoke generation. Insulation adhesive shall be UL listed. Panels shall be double-wall construction with interior wall constructed of solid, galvanized steel. Insulation shall be 1 1/2-lb/ft³ or 3-lb/ft³ density. Thermal resistance (R) shall be 8.33 ft²•h•deg. F/Btu. Provide double wall access panels for access to all major elements. Doors shall be hinged with locks and shall be gasketed. Framework shall be of angle iron members. Channel reinforced panels or panels with integrally formed framework will be acceptable. Panels shall be removable for access to interior. Casings shall be chemically prepared, phosphatized, rinsed, and thoroughly dried prior to receiving enamel finish. 1-1/2 pound fiberglass insulation shall be sandwiched between panel inner and outer skin. Connecting channels shall be insulated to prevent condensation. Provide gasketing where modules are joined. Provide minimum 8 inch high structural base below entire unit.
 - 2. Drain Pans: Provide double wall insulated drain pans under entire fan and coil section. Liner shall be of 304 stainless steel. Insulation shall be sandwiched between liner and outer shell. Pan shall have drain outlets on both sides.
 - 3. Fans: Double width, double inlet, multi-blade type centrifugal blowers fabricated of steel with protective coating; non-overloading airfoil, backward curved blades as scheduled. Fan shall be statically and dynamically balanced. Shaft shall be of steel and sized to operate at 20 percent or more below the first critical speed for the class of duty. Shaft shall be turned, ground and polished to give accurate bearing and hub fit. Fan and motor assembly shall be internally isolated from unit casing with spring isolators provided by unit manufacturer, complete with seismic restraints and flexible connection between fan scroll and unit casing. Isolators shall be as specified in Section 232400, and unit manufacturer shall provide seismic certification in accordance with the requirements of Section 232400.
 - 4. Bearings: Grease lubricated, pillow block, self-aligning ball bearings. Each bearing shall be rated for L50 200,000 hour average life.
 - 5. Motor and Drive: Adjustable motor base V-belt drive package with drive combination selected for 150 percent of motor horsepower and to allow 10 percent higher and 10

percent lower speed adjustment. For drive combination requiring more than two (2) belts operating in parallel, non-adjustable pulleys may be used. Unit manufacturer shall be required to furnish a second drive combination set, in exchange for the original set when required, in order to obtain the proper system delivery in the field. Motor horsepower, voltage, phase, and speed characteristics shall be as specified in the Equipment Data Schedule on the drawings. Motor shall be energy-efficient type, suitable for use with a variable speed drive. Motor shall be as specified in specification Section 230500.

6. Water Coils: Aluminum fins on copper tubes, cartridge type, removable without dismantling entire unit, and shall be drainable. See HEAT TRANSFER COILS article and tempering coil article of this section of these specifications.
7. Mixing Section: Provide a mixing section as detailed on drawings. Provide outside air and return air dampers. Dampers shall be parallel blade type installed to direct air into merging air streams for maximum mixing. Dampers shall have flexible metal jamb seals and gasketed edges and shall rotate on stainless steel bearings. Maximum blade length shall be 60 inches. Leakage shall not exceed 5 cfm/sq. ft. at 1 inch w.g. differential pressure.
8. Filter Section: Side access filter section with pre-filters and filter media as specified in air filter article of the section.
9. Damper Motors: Provided under Section 239500.

- C. Unit Acoustics: Acoustical performance shall be provided based on AHRI Standard 260 fan in unit testing. Provide units as listed below with the following maximum sound power levels in dB, re 10^{-12} W. Data provided in Sones or Bels is not acceptable.

Unit Tag	* Location	Octave Band Center Frequency, Hz							
		63	125	250	500	1000	2000	4000	8000
AHU-1 & AHU-2 (32,000 cfm)	D	81	87	91	90	90	91	86	80
	I	82	76	86	79	78	80	76	65
	C	87	86	85	82	82	72	75	71
AHU-3 & AHU-4 (2,800 cfm)	D	85	87	77	86	82	79	78	80
	C	77	78	75	78	77	69	66	63

* D = Ducted Discharge, I = Ducted Inlet, C = Casing

- D. Unit Performance:

1. All performance shall be as scheduled on drawings. The airflow and external and total static pressures are tabulated. If submitted units exceed the scheduled static and/or scheduled motor size, the manufacturer shall furnish a larger motor as required and shall assume any extra cost incurred by the ELC to wire the motor.
2. See Equipment Data Schedule for motor power characteristics.

- E. Manufacturer: Units shall be by Trane. Units by Daikin (McQuay), JCI (York) or Carrier, meeting the above specifications will be considered for approval.

2.2 HEAT TRANSFER COILS

- A. Water Coils:

1. General: Furnish and install heat transfer coils for air handling units as shown and as scheduled and complying with the following specifications.

2. Construction:

- a. All coils shall be ARI certified.
- b. 5/8 inch OD 0.024 inch wall seamless copper tubing rolled into headers or brazed into header holes with brazing alloys.
- c. Coil circulation shall be arranged to maintain proper water velocity and pressure drop under specified conditions.
- d. Not less than 0.009 inch thick aluminum fins - Fin collars shall be full drawn to provide accurate control of fin spacing and to completely cover the tube for maximum heat transfer. Number of fins per inch shall not exceed twelve (12). Circuiting is not critical as long as the overall coil design meets the performance required.
- e. Headers shall be made of cast iron, galvanized steel or seamless copper tubing and shall be drainable for freeze protection when coils are installed level. Coils shall have connections for either right or left hand arrangement as required; connections shall be steel for ferrous piping and red brass or copper for copper piping. See drawings.
- f. Casing shall be die formed and of not less than 16 gauge stainless steel with reinforced mounting flanges.
- g. Coil assembly shall be supported by intermediate tube supports for rigidity, shall be factory tested under minimum 300 psig pressure, and guaranteed for 200 psig working pressure.

3. Performance: See drawings for performance schedule.

- B. Manufacturer: Coils shall be by Trane. Coils by Daikin (McQuay), JCI (York) or Carrier, meeting the above specifications will be considered for approval.

2.3 AIR FILTERS

- A. General: Provide filters of the type indicated on the drawings and as scheduled below. Filter units shall be complete with frames, housing, filter media, manometers, and all miscellaneous accessories required to form a complete unit.

B. Construction:

1. Housings:

- a. Side Loading Type: Units shall consist of a completely factory-assembled housing by air handling unit manufacturer. Housings shall be constructed of suitable reinforced 16 gauge galvanized steel and shall be lined with 1 inch, 1-1/2 pound density neoprene-coated fiberglass insulation. Access doors with continuous internal perimeter gasketing and positive locking devices shall be provided at both sides of the housing. Leakage into housing from atmosphere shall not exceed 0.5 percent at 3 inches w.c. negative pressure. Filter cartridges shall be inserted through access doors and retained in holding frames or lever locking slide channels which shall incorporate a gasketing material to prevent air leakage between the upstream and downstream sides of the filters. Leakage at rated airflow around filters shall be less than 1 percent at 3 inches w.c. differential pressure across filters. Filter casing shall be complete with channels for 2 inch prefilters.

2. Filter Media:

- a. Filter Media: Filter cartridges shall be replaceable and shall be of a non-supported, deep-pleated design fabricated of fine fibered all glass media. Filter media shall be listed as Class 2 by UL. Each cartridge shall be complete with a galvanized steel frame suitable for insertion into the filter housing. Filters shall have a rated efficiency of MERV 13 percent in accordance with the ASHRAE Standard 52-76 test method using atmospheric dust.

- b. Flat-Filter Media: Provide 4 inch thick, 25 percent (ASHRAE 52-76) efficient non-woven cotton media with 24 gauge, 1 inch x 1 inch electro-finished wire filter media backer bonded to the media. Frame shall be heavy duty paperboard bonded to the media.
 - 3. Draft Gauges: Provide for each filter bank on Dwyer Model 2000 Series, 0 to 3 inch w.g. magnehelic gauge with two (2) 3-way vent valves and all required tubing and fittings for a complete installation.
 - C. See Schedule on drawings for Filter Performance:
 - D. Media Installation: Provide temporary 2 inch thick glass fiber throwaway filters for use during the cleaning and testing of the systems. Air handling units shall not be operated without these filters. Upon Owner acceptance of the systems, remove and dispose of temporary filters and install the permanent media.
 - E. Manufacturers: Filters shall be as manufactured by American Filter or CAM-Farr.
- 2.4 MODULAR BOILER
 - A. General: The boiler plant shall consist of hydronic boiler(s) modules. Boiler modules shall be natural gas fired; condensing fire tube design with a modulating forced draft power burner and positive pressure vent discharge. Each boiler shall be UL Listed, CSD-1 approved, ASME coded and stamped. The boiler control panel shall be of a modular component design with the boiler flame safeguard control, temperature controller and annunciator board field replaceable. The boiler shall have an ASME approved relief valve.
 - B. Construction:
 - 1. Modulating Air/Fuel Valve and Burner: The boiler shall be capable of a 20 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall be nozzle mix design, with spark ignition and flame rectification. The burner shall be cast stainless steel. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. The air and natural gas input shall be metered by a modulating air/fuel valve. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment.
 - 2. Pressure Vessel/Heat Exchanger: The boiler shall be capable of handling return water temperatures down to 40 deg. F. without any failure due to thermal shock or fireside condensation. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. The boiler water connections shall be 4 inch flanged 150 lb. ANSI rated. The pressure vessel is constructed of SA53 carbon steel, with a 0.25 inch thick wall and 0.50 inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The boiler shall be designed so that the terminal efficiency increases as the boiler firing rate decreases. The heat exchanger shall be constructed of 316L stainless steel fire tubes and tube sheets with a one-pass combustion gas flow design. The fire tubes shall be 5/8 inch OD with no less than 0.065 inch wall thickness. The upper and lower stainless steel tube sheets shall be no less than 0.313 inch thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tube sheets and heat exchanger is available by burner and exhaust manifold removal. Minimum access opening shall be no less than 13.5 inch diameter.
 - 3. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant porcelainized cast iron with an 8 inch diameter flue connection. The exhaust manifold shall have a gravity drain for the elimination of the condensation with collecting reservoir.
 - C. Boiler Controls: The boiler controls shall be Underwriters Laboratories Recognized. The combustion safeguard/flame monitoring system shall incorporate a U/L recognized combustion safeguard system utilizing spark ignition and a rectification type flame sensor. An electro-hydraulic double seated safety shutoff valve with proof of closure switch shall be an inherent

part of the gas train. Each boiler shall incorporate an electric type low water level cutoff with test and manual reset and dual over-temperature protection with manual reset in accordance with ASME section IV and CSD-1. Remote fault alarm contacts, sensor failure detection and boiler status and failure annunciator shall be standard equipment.

1. Temperature Control Modes: Boiler(s) shall operate in the control modes listed below.
 - a. Internal set point
 - b. Indoor/outdoor Reset
 - c. 4 mA to 20 mA temperature set point
 - d. 4 mA to 20 mA direct drive
 - e. Boiler Management System (BMS)
 - f. Combination Control System (CCP)
2. Internal Set point: Boiler shall include integral factory wired operating controls to control all operation and energy input of the boiler. Control of discharge water discharge water temperature shall be set through an internal set point with an adjustment of 50 deg. F. to 200 deg. F. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler and without header temperature swings. The boiler will operate to maintain a constant header temperature outlet to +2 deg. F. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Controls shall be fully field adjustable from 50 deg. F. to 200 deg. F. in operation. Main header outlet temperature shall not be more than +2 deg. F. from set point at any point of operation. The boiler shall have LCD display for monitoring of all sensors and interlocks.
3. Indoor/Outdoor Reset: Boiler shall include integral factory wired operating controls to control all operation and energy input of the boiler plant. The system shall be comprised of a microprocessor-based control utilizing pulse width modulation for bumpless transfer of header temperature. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler and without header temperature swings.
 - a. The boiler will operate to vary header temperature set point on an inverse ratio in response to outdoor temperature to control discharge temperature +2 deg. F. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. The boiler shall have LCD display for monitoring of all sensors and interlocks.
4. 4 mA to 20 mA Temperature Set point: Boiler shall include integral factory wired operating controls to control all operation and energy input of the boiler. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler without header temperature swings. The boiler will operate to vary header temperature set point linearly as an externally applied 4 m to 20 mA signal is supplied. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Main header outlet temperature shall not be more than +2 deg. F. from set point at any point of operation. The boiler shall have LCD display for monitoring of all sensors and interlocks.
5. 4 mA to 20 mA Direct Drive: Boiler shall include integral factory wired operating controls to control all operation and energy input of the boiler. The controller shall have the ability to vary boiler input throughout its full range to maximize the condensing capability of the boiler without header temperature swings. The boiler will operate to vary the boiler firing rate linearly as an externally applied 4 mA to 20 mA signal is supplied. Unit shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. The boiler shall have LCD display for monitoring of all sensors and interlocks.
6. Boiler Management System (BMS): The Boiler Manufacturer shall supply as part of the boiler package a completely integrated Boiler Management System Model 168 Programmer to control all operation and energy input of the multiple boiler heating plant.

The Boiler Management System shall be comprised of a microprocessor-based control utilizing a pulse width modulated (PWM) signal to communicate with the boilers. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The BMS shall control the boiler outlet header temperature within +2 deg. F. The controller shall be a PID type controller for accurate temperature control with excellent variable load response. The BMS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

- a. When set on Internal Set point Mode, temperature control set points on the BMS shall be fully field adjustable from 50 deg. F. to 200 deg. F. in operation. When set on Indoor/Outdoor Reset Mode, the BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4 mA to 20 mA Temperature Control Mode, the BMS will operate the plant to vary header temperature set point linearly as an externally applied 4-20 mA signal is supplied. The BMS controller shall have a LCD display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each module by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central BMS system and individual modules shall be twisted pair low voltage wiring, with the boilers "daisy-chained" for ease of installation.
- D. Warranty: The pressure vessel/heat exchanger of the boiler shall carry a seven year prorated, limited warranty against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship. A Warranty Certificate must be issued to the owner from the manufacturer and a copy of warranty be submitted for engineers approval.
- E. Field Services: Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment startup. A letter of compliance with all factory recommendations and installation instructions shall be submitted to the engineer with operation and maintenance instructions.
- F. Performance: As schedule on drawings. See Equipment Data Schedule for electrical power characteristics.
- G. Manufacturer: Boiler shall be as manufactured by Crest boilers by Lochinvar. Boiler shall be factory tested prior to shipment. Clear-Fire Boilers by Cleaver-Brooks, Camus Advantus, and Aerco will be considered for approval.

2.5 LOW TEMPERATURE BOILER VENTS

- A. General:
 - 1. Provide AL29-4C stainless steel vent system as shown on the drawings.
 - 2. Vent system shall be in accordance with boiler manufacturers' recommendations.
- B. Description: Single wall special gas vents conforming to UL-1738. Vents shall be listed for use with the specified boilers.
- C. Construction:
 - 1. Vents shall be AL29-4C stainless steel.
 - 2. All butt seams shall be TIG welded to ensure a gas and watertight seal.
 - 3. Each piece/component of the vent system shall contain a factory built-in gasket and factory built-in locking band.
- D. Accessories: Tees, elbows, connectors, rain cap with bird barrier, roof flashing, storm collar, support assembly, guides, spacers, and fasteners fabricated of similar materials and designs as vent pipe straight sections.

- E. Manufacturer: AL29-4C special gas vent system shall be as manufactured by FasNseal, or by engineer approved alternate.

2.6 VARIABLE FREQUENCY DRIVES (VFD)

A. General:

1. Variable Frequency drive shall be microprocessor controlled drive. Controller shall utilize a modular assembly of diode rectifiers as the converter and a pulse width modulation (PWM) type inverter complete with components necessary to provide variable speed for variable torque loads on motors specified on Equipment Data Schedule.
2. Controllers shall provide variable frequency power supply to energy-saving type squirrel cage induction motors without exceeding motor manufacturer's recommendations. Motors for "inverter duty" or used with IGBT type adjustable frequency converters shall have special motor winding insulation and be in compliance with NEMA MG1-1993 Part 31. Motor insulation system shall meet 1600 volt peak with a rise time of 0.1 microsecond. Exception: Bearings are not required to be insulated. Contractor shall verify compatibility of controllers with motor manufacturer or supplier prior to submittal of shop drawings. Drives shall have sine wave amperage output equal to or greater than the nameplate motor amperage. Drive manufacturer shall request and receive confirmation from manufacturers of the new motors, that use of his VFD will not effect the motor warranty.
3. Controller shall accept 60 Hz + 2 Hz, AC input power of specified voltage + 10 percent, convert it to DC with diodes, and input to bi-polar or insulated gate bi-polar transistor (IGBT) inverter to provide output voltage and frequency to the motor for the desired speed. Adjustable speed control shall have both manual speed control potentiometer and automatic speed control to follow a variable input signal. Automatic, manual and off operations shall be selected by a selector switch or pushbuttons. Controller shall have diagnostic or trouble shooting circuitry and visual indicators.
4. Main Input Disconnect: Variable Frequency Drive (VFD) shall have main input fusible disconnect or molded case circuit breaker mounted within or adjacent to the VFD enclosure or be located above or below the VFD in its own enclosure. Circuit breakers AIC shall exceed the available fault current at the VFD. Input disconnect shall when open, remove all line input power to the drive and to any bypass contactors. Disconnect shall indicate ON/OFF or TRIPPED and have padlockable handle.
5. Enclosure: Controllers shall be mounted in a NEMA 1 metallic enclosure as indicated. Enclosure shall have main input disconnect, VFD controller, motor overloads, control power transformer, main input and bypass contactors, necessary for complete unit. Enclosure shall have necessary heat sinks, louvers and fans to dissipate heat generated by the controller. Top and bottom of enclosure shall have necessary space for field wiring. Fuses shall be easily accessible to allow replacement.
6. Bypass on Fan Controllers: To prevent damage to ductwork, provide the following warning nameplate at bypass controls.

**WARNING!
BYPASS POSITION RUNS FANS
AT FULL SPEED VERIFY ALL DAMPERS
THAT MAY RESTRICT AIRFLOW
ARE IN FULL-OPEN POSITION**

- a. Reference Section 231900 - MECHANICAL IDENTIFICATION for additional nameplate requirements.
7. Environment: Controller shall work satisfactory in ambient temperature range of 32 deg. F. to 104 deg. F. in relative humidity range from 5 to 95 percent.
8. Manufacturer Startup Service and Acceptance Testing: Manufacturer/supplier shall provide startup service and acceptance testing of VFD. Field service technicians shall be factory-certified service representatives highly trained in all aspects of starting-up and acceptance testing of the VFD equipment and shall be current with all the latest product

improvements. Acceptance testing shall be provided in the presence of the Owner's maintenance supervisor as an observer. Services shall include but not be limited to the following:

- a. Inspection of the VFD equipment prior to energization.
 - b. Perform functional and operational tests on VFD equipment.
 - c. Perform all required electrical tests to verify proper operation. Acceptance shall only be after correction of any problems.
 - d. Verify system documentation.
 - e. Observe system functionality and safety checks after energization.
 - f. Provide documentation via a certified test report of test results to be used as a benchmark for future maintenance testing.
 - g. Provide 4 hour on-site training course to the Owner within 6 months after acceptance testing at a time agreeable to the Owner.
9. Factory (Burn-In) Tests: VFD shall be tested at point of manufacture and assembly with squirrel cage motor applied to provide complete testing of electronic equipment over its full load speed range. VFD printed circuit boards and power sections shall be tested or burned-in for minimum of 48 hours with cyclical motor load in 104 deg. F. room ambient to simulate maximum level of temperature and load cycling over full speed range of controller. Certified test reports shall be provided to Architect/Engineer.
10. Warranty: Variable Frequency Drives shall have 2 year warranty by VFD manufacturer from date of startup or 36 months from date of VFD shipment whichever comes first. Warranty shall be against defects in material and workmanship. Warranty shall include parts, labor, material, transportation and living expenses.
11. Standards and Quality Assurance:
- a. Controller shall be UL listed in accordance with UL 508,C "Electric Industrial Control Equipment".
 - b. Controller shall meet the requirements of NEMA ICS 7.1 "Safety Standard for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive System" to provide proper coordination between the controller and the interrupting device during a short circuit.
 - c. Manufacturer shall have minimum of 5 years experience in manufacturing the type VFD specified.
 - d. Manufacturer/supplier shall have permanent service facilities in St. Louis area. These facilities shall on 24 hour call. Service contracts shall be made available to Owner. Complete instruction manual shall be provided to Owner.
12. RFI/EMI Filters: RFI/EMI filters shall be provided on all VFDs that create radio frequency noise in excess of limits specified by FCC Docket 20780 (part 15, subparagraph J) or if noise is in frequency range that will interfere with other building sensitive equipment, telecommunications systems, instrumentation and monitoring equipment. RFI/EMI filters shall meet ANSI C63.12.
13. Talk Between Drives: VFD signals into AC power system shall not affect other VFD on the same AC power system.
14. Total Harmonic Distortion and Test: Manufacturer shall provide harmonics study for each VFD to determine the exact requirements for line reactors and isolation transformer to limit line noise as specified. Contractor shall provide manufacturer with job's one-line diagram with transformer kVA and impedance, feeder sizes and lengths to VFD and point to sensitive electronic equipment and other pertinent information requested by manufacturer.
- VFD shall have input line reactors or shielded drive (UL 561K) isolation transformer as appropriate to limit line noise to 3 percent harmonic current distortion and line voltage notching to no more than 16,400 volt-microsecond commutation area in accordance with IEEE standard 519-1992. Manufacturer shall provide proven compliance with IEEE 519-1992 by providing testing of harmonics after installation of VFD and provide appropriate filters. Manufacturers shall provide Architect/Engineer paper copies of test results to provide proof of compliance.

15. Long Output Leads to Motor: Where wire from the VFD to the motor exceeds the VFD manufacturer's requirements, output line reactors shall be provided as required to reduce the high voltage reflection wave back to the motor terminals to a level well below the voltage rating of the motor winding insulation.

B. Materials and Applications:

1. Controller shall have following minimum ratings and devices:

- | | | |
|----|--|--|
| a. | Power factor | - 95 percent at any speed |
| b. | Speed regulation | - + 1 percent or less |
| c. | Motor speed (rpm) | - 0 to 100 percent (min.) of rated speed. |
| d. | Current limit adjustment | - Running 50 to 110 percent FLA or better. |
| e. | Acceleration time adjustment | - 0.1 to 30 seconds (min. range) |
| f. | Deceleration time adjustment | - 3 to 300 seconds (min. range) |
| g. | Instantaneous trip: | - Provides shutdown to prevent component failure due to any of the following faults. |
| | 1) Overcurrent | - Trips at overcurrent setting |
| | 2) Overvoltage | - Trips at 10 percent overvoltage |
| | 3) Undervoltage | - Trips at 10 percent undervoltage |
| | 4) Overtemperature protection | - Trips at 104 deg. F. ambient |
| | 5) Phase loss | - Trips on loss of any phase |
| h. | Terminals for output wiring for remote status indication of controller in "bypass mode" in and the "running mode." | - Output signals from controller's (Form C) dry contacts rated 5 amps, 120 volts for both signals. |
| i. | Terminals for output wiring for remote indication of controller "at speed." | - Output signals from controller's (Form A) contacts rated 5 amps, 120 volts. |

- j. Terminals for output wiring for remote indication of "drive alarm." Output signals from controller's (Form C) contacts rated 5 amps, 120 volts.
- k. Terminals for input wiring from remote safety devices such as freezestat, or smoke detector. - Safety devices shall not be disconnected by operation of VFD in Automatic, or Manual, or Bypass
- l. Terminals for output wiring for remote status indication of "controller failure." - Output signals from controllers (Form C) contacts rated 5 amps, 120 volts
- m. Control transformer - 120 or 24 VAC output
- n. Heat control - Heatsink construction with blower motors with air filters when required to meet VFD installed ambient requirements.
- o. Motor overload protection trip - Solid-state adjustable type or relay type with manual reset
- p. Main input disconnect (reference preceding "General" paragraph for additional details.) - Disconnects all three-phase inputs
- 2. Short Circuit Protection: Minimum 25 kAIC. Controller shall have short circuit protection via fuses that will protect controller from damage of phase-to-phase fault and ground fault sensors to protect against phase-to-ground faults.
- 3. Remote Control:
 - a. Automatic Speed Control: Controller shall accept variable input follower signal for speed control. Input signal shall be either 0 to 135 ohm, 0 to 10 VDC, or 4 to 20 mA DC from Direct Digital Controller (DDC) as necessary to provide automatic speed control of motor when controller is in "automatic mode." Controller supplier shall provide transducers where necessary.
 - b. Start/Stopping: Drive shall accept two-wire or three-wire control, either 115 VAC or 12 VDC.
 - c. Remote Contact Closure Input Signals: Unit shall have terminals to receive wiring from remote input signals to stop motor from remote safety devices on the fan or pumping system, with drive in either normal or bypass mode of operation.
- 4. Indicator and Controls on Doors: Doors of controllers shall have the following minimum equipment:
 - a. Speed indicating meter, LED or LCD display
 - b. Manual speed control (when H-O-A switch is in HAND).
 - c. Stop/start or stop/run pushbuttons
 - d. Hand-off-automatic selector switch or manual-off-automatic pushbuttons
 - e. Run indication
 - f. Normal/bypass or inverter/bypass selector switch
 - g. Arrow or plus and minus push buttons for scrolling through displays or changing value of a programmable parameter.

5. Bypass Contactors: Bypass contactors and drive disconnect shall be in enclosure with Variable Frequency Drive. Bypass contactors shall be on load-side of main input disconnect. Bypass contactors shall permit motor to be manually switched to Bypass mode from Normal mode upon failure of VFD. Bypass shall be performed by opening set of contacts on VFD output and closing set of contacts that bypass VFD drive. The main input disconnect shall permit VFD to be removed from input power thus permitting maintenance of VFD drive. In the Bypass mode the motor will operate at a single speed, however, all system safety devices and motor overloads shall remain in the motor control circuit. Auxiliary contacts and terminals shall be provided to permit control of motor by DDC Building Management System when the VFD controller is in Normal or Bypass mode. Audible noise difference of motors when run on VFD or bypass shall be negligible.
 6. Ride Through: Controllers shall ride through power dips of 500 ms.
 7. Automatic Restart: Automatic synchronizes restart upon return of power after a power failure shall be provided. For momentary power failures drive shall be able to synchronize with deceleration of the rotating motor. After three (3) attempts to synchronize, if unit fails it shall shutdown.
 8. Critical Frequency Jump or Frequency Avoidance Bands: Provide band width controls to avoid mechanical resonance (vibration) at a minimum of three (3) points.
 9. Fault History Record: Unit memory shall retain and record run status and fault type of the last three (3) faults.
 10. Tester board or test meter shall be provided to owner to simplify troubleshooting. Testing devices integral with drive will be acceptable.
- C. Manufacturer: Manufacturer of PWM controller (IGBT type) shall be Toshiba International Corp. (Q7 Series). Units by ABB (ACH550), Yaskawa (E7), Danfoss (VLT HVAC), or Eaton Corp. (HVX9000), meeting the above specifications will be considered for approval.

2.7 DUCTLESS SPLIT COOLING SYSTEM

A. Wall-Mounted Air Handling Unit:

1. General: Provide air handling room unit where shown on drawings. Unit shall be self-contained, factory piped and wired and arranged for connection to remote air-cooled condensing unit.
2. Cabinet:
 - a. The indoor unit cabinet shall be wall mounted by means of a factory supplied mounting plate. The cabinet shall be formed from high strength molded plastic with front panel access for filter.
 - b. The indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor.
 - c. The unit in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory.
3. Fan: The evaporator fan shall be high performance, double inlet, forward curve, direct drive fan with a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four (4) speeds: Low, M1, M2, and Hi.
4. Vane: There shall be a motorized horizontal vane to automatically direct airflow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower noise levels, and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.
5. Filter: Return air shall be filtered by means of an easily removable washable filter.

6. Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
7. Electrical: The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
8. Control: The control system shall consist of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Two (2) 20 ga. AWG wire shall be run between the units to provide for bi-directional control communication. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit. The indoor unit shall be connected to a wall mounted wired controller to perform input functions necessary to operate the system. The wired controller shall have a large liquid crystal display (LCD).

B. Condensing Unit:

1. General: Provide condensing unit with holding charge of nitrogen. Units shall be designed to operate between 0 deg. F. and 115 deg. F. ambient temperature. Units shall be designed for outside application.
2. The outdoor unit shall be equipped with a control board that interfaces with the indoor unit to perform all necessary operation function. The outdoor unit shall be able to operate with a maximum height difference of 100 ft. between indoor and outdoor units and with a maximum refrigerant tubing length of 100 ft. without the need for line size changes, traps or additional oil. Units shall include pre-charged refrigerant tubing, maximum of 70 ft. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.
3. Cabinet: The casing shall be constructed from galvanized steel plate, coated with a finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection. The fan grille shall be of ABS plastic.
4. Fan: The fan motor shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent contact with moving parts.
5. Coil: The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of linear expansion valve (LEV) metering orifice. The LEV shall be control by a microprocessor controlled step motor.
6. Compressor: The compressor shall be a DC rotary compressor with Variable Compressor Speed Inverter Technology. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be intermittently applied to the compressor motor to maintain enough heat. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.
7. Electrical: The electrical power of the unit shall be 208volts or 230 volts, 1 phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts. The outdoor unit shall be controlled by the microprocessor located in the

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Webster University
Cannon Design Project No. 004561.01**

indoor unit. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

- C. Performance: See schedule on drawings. See Equipment Data Schedule for electrical power characteristics.
- D. Accessories:
 - 1. Wireless controller
 - 2. Pre-charged refrigerant line set
 - 3. Mounting hardware
- E. Quality Assurance:
 - 1. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.
 - 2. All wiring shall be in accordance with the National Electrical Code (NEC).
 - 3. The units shall be rated in accordance with Air-conditioning Refrigeration Institute's (ARI) Standard 210 and bear the ARI Certification label.
 - 4. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
 - 5. A dry air holding charge shall be provided in the indoor section.
 - 6. The outdoor unit shall be pre-charged with R-410a refrigerant for 70 ft. of refrigerant tubing.
 - 7. System efficiency shall meet or exceed 13.0 SEER.
- F. Warranty: The units shall have a manufacturer's parts and defects warranty for a period one (1) year from date of installation. The compressor shall have a warranty of 6 years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.
- G. Manufacturer: Unit shall be by. Units by Trane. Units by Daikin, Mitsubishi Electric (Mr. Slim), or Sanyo HVAC meeting the above specifications will be considered for approval.

2.8 LABORATORY EXHAUST FANS (MIXED FLOW, INDUCED DILUTION TYPE)

- A. General: Provide mixed flow, induced dilution type laboratory exhaust fans. Fans shall be tested under AMCA 210-85, "Laboratory Methods of Testing Fans for Rating." Sound testing shall be in accordance with AMCA 300. Fans shall be UL listed per UL 705 safety standard.
- B. Construction:
 - 1. Impellers shall be mounted directly to the motor shaft to provide direct drive arrangement 4 type fans. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service.
 - 2. Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading performance characteristics with stable operation at any point on the fan curves.
 - 3. Fan and all drive components shall have a combined bearing life of up to $L_{10} = 150,000$ hours.
 - 4. Provide stationary discharge guide vane sections.
 - 5. Fan dynamic balance shall not exceed 0.5 mil, peak-to-peak, at the blade pass area when operating at fan frequency. Vibration isolation shall be rubber-in-shear pad type isolators.
 - 6. Fan discharges shall include twin FRP nozzles with passive third central stacks that are capable of generating aspiration. Provide integral nozzle silencer. The FRP shall be chemically and UV resistant.
 - 7. Steel entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static

pressure requirements. Windbands shall discharge up to 270 percent of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.

8. Provide a non-ferrous inlet bell in order to reduce sparking in the event of a motor bearing failure.
9. Provide PTFE gaskets at all companion flange joints.
10. Fasteners shall be 316 stainless steel.
11. A bolted access door shall be provided for impeller inspection of each fan.
12. Fans and accessories shall have internal drain systems to prevent rainwater from entering building duct system.
13. Electric motors shall be TEFC with a 1.15 service factor and an L-10 bearing life of 150,000 hours. Provide premium efficient motors with regreasable bearings and grease relief fittings.
14. Provide extended motor lube lines covered with braided stainless steel. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line.
15. Provide a NEMA 3R non-fused disconnect switch.
16. Provide 8-10 mil epoxy coating on all steel and aluminum surfaces. Prepare surfaces for coating by blasting or chemical etching.

C. Accessories:

1. Inlet mixing plenum: Provide inlet mixing plenum sized to support the weight and performance requirement of the fans. Multiple-fan plenums shall be insulated double wall construction with structural stiffeners. Double wall plenums shall have an overall minimum wall thickness of 1-1/2 inches, and the insulation shall have a minimum R value of 4. Outer skin of double wall plenums shall be coated 12 gauge galvaneal steel. Inner skin shall be uncoated 18 gauge stainless steel. Multiple fan plenums shall be able to withstand a minimum of 12 inch w.g. of negative pressure. The plenums shall include hinged access doors and stainless safety screens over bottom primary fan inlets.
2. Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Dampers will be opposed blade low leakage airfoil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. Rain hoods shall be provided with each damper. The dampers shall be controlled by 24 volt electric operators.
3. Low leakage isolation dampers shall be constructed of aluminum airfoil extrusions and epoxy coated 10 mils DFT. Operators shall be 2 position, spring return and shall be 24 volt electric unless variable frequency drives are specified. Electric operators shall be factory wired (via a transformer when required) to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.
4. Provide an acoustical silencer nozzle designed as an integral component of the exhaust fan discharge nozzle. The published insertion loss values shall be obtained from an AMCA 300 test with the silencer installed on the fan specified. Ratings based on separate silencer and fan testing is not acceptable. The silencer shall be constructed with an outer shell of fiber reinforced plastic with a minimum of 3/16 inch wall thickness. The inner liner shall be perforated corrosion resistant steel. The silencer should be colored to match the fans. Acoustic media shall be 3 pound density fiberglass isolated from the air stream by a tedlar film, non-fibrous acoustical media.
5. Provide heating recovery coils as specified in "Heat Transfer Coils" section of these specifications.
6. Vortex breakers shall be provided on all multiple fan plenums.
7. Provide 18 inch high seismic roof curb, see Section 232400.

- D. Warranty:** Provide a 7 year warranty from time of purchase to include fan, motor and all drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts.

- E. Performance:
 - 1. See Schedule on drawings.
 - 2. See Equipment Data Schedule for motor power characteristics.
- F. Manufacturer: Provide fans by Strobic Air Corporation. Equipment by Greenheck, Cook, or Twin City, meeting the above specifications will be considered for approval.

2.9 IN-LINE CENTRIFUGAL FANS

- A. General:
 - 1. Description: Belt-driven duct-mounted in-line centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
 - 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - 3. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal for both air and sound.
 - 4. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
 - 5. UL Standard: Fans shall comply with UL 705.
- B. Construction:
 - 1. Housing: Fan housing shall be square-shaped and fabricated of minimum 18 gauge galvanized steel and integral duct collars. Sides of casing shall be formed and braced to provide a rigid assembly. Housing shall include a minimum of two (2) removable gasketed access panels of sufficient size to permit easy access to all interior components. Housing shall be furnished with mounting brackets for vertical or horizontal mounting.
 - 2. Fan Wheels: Non-overloading, aluminum wheel, hub and inlet cone with backward-inclined blades, dynamically and statically balanced.
 - 3. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub. First critical shaft speed shall be a minimum of 125 percent of fan's maximum operating speed.
 - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning, L10 100,000 hour ball bearings. Bearings shall be designed and tested for air handling applications.
 - c. Pulleys: Cast-iron, adjustable for ± 10 percent of rated rpm.
 - d. Fan and motor assembly isolated from exhaust airstream and mounted on combination shear and compression-type neoprene isolators.
 - e. Drives shall be selected for 150 percent of installed motor horsepower.
 - f. Belts shall be oil and heat-resistant, non-static type.
 - 4. Motors: Comply with requirements in Division 23 Section 230500. Motor construction shall be open dripproof.
- C. Accessories:
 - 1. Acoustically lined housing
 - 2. Disconnect Switch: Non-fusible type with thermal-overload protection.
 - a. Factory-wired and mounted in NEMA 1 enclosure.
 - 3. Backdraft Damper: Gravity-type, parallel-blade aluminum blades and frame with nylon bushings.
 - 4. Motor Cover/OSHA Belt Guard: 18 gauge galvanized steel with open back for inspection and belt tensioning without removing guard.

- D. Performance:
 - 1. See Schedule on drawings.
 - 2. See Equipment Data Schedule for motor power characteristics.
- E. Manufacturer: Equipment shall be by Greenheck. Equipment by Penn Barry or Cook meeting the above specifications will be considered for approval.

2.10 CEILING-MOUNTED EXHAUST FAN

- A. General:
 - 1. Description: Centrifugal fans designed for installing in ceiling or for concealed in-line applications.
 - 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - 3. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal for both air and sound.
 - 4. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
 - 5. UL Standard: Power exhaust fan shall comply with UL 705.
- B. Construction:
 - 1. Housing: Galvanized steel, acoustically lined.
 - 2. Fan Wheel: Centrifugal forward curved wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
 - 3. Motor: NEMA 1 construction, permanently lubricated, low rpm, ball bearing motor, with thermal overload protection, and internal plug-in type disconnect. Motor shall be mounted on vibration isolators.
 - 4. Grille: High-impact plastic inlet grille with white, non-yellowing finish and thumbscrew attachment to fan housing.
 - 5. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Integral, non-metallic backdraft damper.
 - c. Motion Sensor: Motion detector with adjustable shutoff timer for shower rooms only.
 - d. Brick vent with medium bronze anodized finish.
- C. Performance:
 - 1. See Schedule on drawings.
 - 2. See Equipment Data Schedule for motor power characteristics.
- D. Manufacturer: Units manufactured by Greenheck. Equipment by Cook, or Penn Ventilator, meeting the above specifications will be considered for approval.

2.11 CENTRIFUGAL UPBLAST ROOF EXHAUST FAN

- A. General:
 - 1. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
 - 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - 3. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal for both air and sound.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

4. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
5. UL Standard: Power exhaust fans shall comply with UL 705. Power exhaust fan shall comply with UL 762 for handling grease-laden air.

B. Construction:

1. Housing: Leakproof fan housing constructed with a one-piece windband with an integral rolled bead. Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum curb cap with Venturi inlet cone; and stainless steel fastenings. Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and aluminum grease collector and drain. Housing shall be joined to the curb cap with a continuously welded seam.
2. Fan Wheels: Non-overloading, aluminum hub and wheel with backward-inclined blades, dynamically and statically balanced.
3. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning, L50 200,000 hour ball bearings.
 - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - d. Fan and motor assembly isolated from exhaust airstream and mounted on combination shear and compression-type neoprene isolators.
 - e. Drives shall be selected for 150 percent of installed motor horsepower.
4. Motors: Comply with requirements in Division 23 Section 230500. Motor construction shall be NEMA 1, general purpose or NEMA 7, explosionproof (gases and vapors), as applicable. Enclosure type shall be totally enclosed, fan cooled.
5. Conduit Chase: Internal conduit through the curb cap into the motor compartment for electrical wiring.
6. Accessories:
 - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - b. Disconnect Switch: NEMA 3R enclosure, non-fusible type, with thermal-overload protection mounted outside fan housing, factory wired through an internal aluminum conduit.
 - c. Bird Screens: Removable, 1/2 inch (13 mm) mesh, aluminum or galvanized.
 - d. Dampers: Gravity-type, parallel-blade, backdraft dampers mounted in curb base.
 - e. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 - f. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2 inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2 inch wood nailer. Size as required suiting roof opening and fan base.
 - 1) Configuration: Self-flashing without a cant strip, with mounting flange
 - 2) Overall Height: 12 inches.
 - 3) Pitch Mounting: Manufacture curb for roof slope.
 - 4) Metal Liner: Galvanized steel.
 - 5) Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
 - 6) Vented Curb Extension: Unlined with louvered vents in vertical sides. Curbs for grease exhaust fans shall be 18 inches high. Duct shall extend up into curb and connect directly to fan inlet.

C. Performance:

1. See Schedule on drawings.
2. See Equipment Data Schedule for motor power characteristics.

- D. Manufacturer: Units manufactured by Greenheck. Equipment by Cook, Carnes, or Penn Ventilator, meeting the above specifications will be considered for approval.

2.12 PUMPS (IN-LINE)

- A. General: Provide where indicated on the drawings, "in-the-line" circulating pumps as scheduled on the plans and in accordance with the following specification.
- B. Construction:
 - 1. Vertical in-line, cast iron, bronze fitted, grease-lubricated type, specifically designed and guaranteed for quiet operation. Pumps shall be suitable for 175 psig working pressure.
 - 2. Ground and polished stainless steel shaft with lubricable bearings. Motor shall be non-overloading at any point on pump curve. Impeller shall be of the enclosed type, dynamically and hydraulically balanced, and keyed to the pump shaft.
 - 3. Pump shall utilize a mechanical seal with a carbon seal ring and ceramic seat.
 - 4. Motors shall be rpm as scheduled and shall be of open dripproof design with lubricable ball bearings.
 - 5. Pumps shall be complete with companion flanges, suction and discharge and vent tapings.
 - 6. See Equipment Data Schedule for motor characteristics. Pumps 10 horsepower and smaller shall be close coupled. Pumps larger than 10 horsepower shall be provided with spacer coupling. Spacer coupling shall allow replacement of pump shaft seal with out disturbing motor or pump connections.
 - 7. Pumps shall be factory finished with machinery enamel.
- C. Installation: Pumps shall be supported by a spring hanger approved by the pumps manufacturer. The spring shall support the pumps at the approximate center of gravity and shall reduce the piping load to no more than 10 percent of the pump weight.
- D. Performance Data: See plans.
- E. Manufacturers: Pumps shall be Series 60, 80SC, or series PL as manufactured by Bell & Gossett. Pumps by Armstrong, FLO FAB or Taco, meeting the above specifications will be considered for approval.

2.13 PROPELLER UNIT HEATERS

- A. General:
 - 1. Description: A factory-assembled unit including casing, coil, fan and motor with adjustable discharge louvers.
 - 2. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - 3. Heating Coils: Tested and rated according to ASHRAE 33.
- B. Construction:
 - 1. Casing shall be fabricated of minimum 18 gauge sheet metal and shall be phosphatized and painted with baked enamel. Cabinet shall be constructed for horizontal or vertical airflow as scheduled. Horizontal units shall be complete with adjustable discharge louvers.
 - 2. Fan shall have aluminum blades and shall be factory balanced.
 - 3. Coil shall be fabricated of seamless copper tubing with aluminum fins mechanically bonded to tubes. Coils shall be tested to 300 psig air pressure under water.
 - 4. Motors shall be totally enclosed shaded pole or permanent split capacitor type with integral thermal overload protection and with sleeve or ball bearing motors. Motor shall be secured with vibration isolation type mountings.
- C. Performance: See schedule on drawings.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- D. Accessories: Provide the following:
 - 1. Inlet OSHA fan guard
 - 2. Remote thermostat
- E. Manufacturer: Equipment shall be by Trane. Equipment by Daikin, Vulcan, Rittling, or Sterling, meeting the above specifications will be considered for approval.

2.14 CABINET UNIT HEATERS

- A. General:
 - 1. Cabinet unit heaters shall be complete with factory-assembled chassis, coil, fans, controls, motor, insulation, and housing.
 - 2. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70 Article 100 by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - 3. Heating Coils: Tested and rated according to ASHRAE 33.
 - 4. Unit capacities shall be in accordance with ARI.
- B. Construction:
 - 1. Cabinets shall be fabricated of minimum 18 gauge steel removable panels with tamperproof fasteners, and shall be reinforced as required for forming a rigid cabinet. Vertical wall hung units shall have minimum 16 gauge front panels. All cabinet parts shall be bonderized, phosphatized and finished with baked enamel, color selected by Architect. Inlet and outlet grilles shall be stamped into the cabinet for vertical cabinets. Vertical units shall have a flat top. Bottom panels on horizontal units shall have tamperproof screw fasteners and safety chain.
 - 2. Hot Water Coils shall be fabricated of minimum 3/8 inch O.D. seamless copper tubes with mechanically bonded aluminum fins, and 5/8 inch O.D. copper stubouts. Coils shall be burst tested at 450 psig and leak tested at 100 psig air pressure under water. Maximum coil working pressure is 300 psig.
 - 3. Fans: Fan wheels shall be of the forward curved, double width, centrifugal type, fabricated of aluminum. Fan scrolls shall be fabricated of steel with galvanized or baked enamel finish. Fans shall be statically and dynamically balanced.
 - 4. Insulation: Entire cabinet shall be lined with minimum 1/2 inch thick, closed cell insulation with a flame spread not to exceed 25 and a smoke developed rating not to exceed 50.
 - 5. Filters: Units shall be complete with glass fiber throwaway type filters.
 - 6. Motors shall be 2 speed and of the permanent split capacitor type with integral thermal overload protection and quick disconnect plug. Motors shall be permanently lubricated.
 - 7. Motor Control: Unit shall be complete with factory-mounted and wired thermostat and speed control switch. Provide motor cord and junction box for electrical service. Access door to fan control shall be tamperproof.
 - 8. Automatic Control: Provide a 2 way, 2 position, electric, normally open control valve controlled from an integral return air sensor. Upon a call for heat, the valve shall open and the fan shall operate at the speed determined by the motor selector switch.
- C. Performance:
 - 1. Unit shall be as scheduled on drawings.
 - 2. See Equipment Data Schedule for motor power characteristics.
- D. Accessories:
 - 1. Remote thermostat with unit mounted fan speed switch. Provide motor cord and junction box for electrical service. Access door to fan control shall be tamperproof.
 - 2. Service valves, unions, strainer and balancing valve factory installed with control valve.
 - 3. Recessing flanges
- E. Manufacturer: Equipment shall be by Trane. Equipment by Daikin, Vulcan, Rittling, or Sterling, meeting the above specifications will be considered for approval.

2.15 FINNED TUBE RADIATION

- A. General: Provide, where indicated on the drawings and as scheduled, all finned tube radiation complete with all accessories to result in a finished installation. Ratings shall be in accordance with the Hydronic Institute's "I=B=R Testing and Rating Standard for Finned Tube (Commercial) Radiation".
- B. Heating Elements: Seamless copper tubes, mechanically expanded into flanged collars of evenly spaced aluminum fins, minimum 0.016 inch thick. Radiation shall have cradle-type element supports to allow unrestricted longitudinal expansion and contraction without strain or noise. All elements shall be factory-tested for a working pressure of 150 psig at 300 deg. F. temperature.
- C. Finned tube radiation shall consist of bare element units or radiant panels. Enclosure shall be of adequate length to completely fill allocated space for radiation. Front panels shall be individually removable. Enclosure shall have flush joints with no visible fastening devices. Gussets and vertical stiffeners shall be provided at enclosure joints.
- D. Radiant panel finned tube radiation:
 - 1. Provide steel double panel radiators of the lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The double heating panel radiation shall be of one-piece all-welded steel construction, consisting of a pair of flattened water tube panels welded to headers at each end. Welded to the inside of each panel shall be steel corrugated fins to increase the convective output of the radiator. The fins shall start at no less than 3 inch from the end of the radiator, and shall have no less than 32 fins per foot. The radiators shall include an integral heavy gauge (0.09" minimum) all-welded perforated top grille, which will cover the top of all of the finned areas (for curved radiators the grille is omitted).
 - 2. The headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are 1/2 inch NPT tapered thread for supply and return piping, and 1/8 inch for the vent connection. Internal baffling is provided where required for proper water flow.
 - 3. The radiant heating panels shall be available in lengths from 2 ft.-0 inch to 29 ft.-6 inch in 2 inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets shall be provided with the radiation.
 - 4. The double panel radiators (up to four tubes tall) are to be provided with floor-mounted pedestals or Cantilever Wall Brackets in lieu of the wall mounting brackets.
 - 5. Pressure Ratings: Pressure ratings for the radiation shall be 85 PSI maximum, Working pressure and Test Pressure-110 PSI maximum.
 - 6. Panel radiation expansion shall not exceed 1/64 inch per foot of radiation at 215 deg. F. The installer shall provide adequate expansion compensation for each radiator.
 - 7. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002 inch - 0.003 inch). The color shall be selected from the Runtal's standard colors, or optional colors shall be available at an additional cost. Enclosure/panels shall have factory finish of color selected by Architect.
 - 8. Warranty: All Runtal radiators are covered by a 5 Year Limited Warranty.
- E. Accessories:
 - 1. All required end trim, end enclosures, mitered corner pieces and extensions to complete the installation. All accessories shall overlap with enclosure joints. All trim shall match finish/color of enclosure and grille.
 - 2. Access section with hinged access door and tamperproof lock at each valve.
 - 3. Air seal gasket.
- F. Performance: See schedule on drawings.

- G. Manufacturer: Equipment shall be by Runtal. Equipment by Vulcan, Sterling, Rittling or Trane, meeting the above specifications will be considered for approval.

2.16 PLATE HEAT EXCHANGER

- A. General: Provide water-to-water plate heat exchangers as scheduled and as specified below.
- B. Construction:
1. Plate type heat exchanger shall be arranged for counterflow and consist of gasketed, individually removable, channel plates supported by a frame and carrying bars and bolted between one fixed and one movable pressure plate. All wetted parts shall be of stainless steel plus an aluminum splashguard as required by OSHA. Channel plate ports shall be double gasketed to prevent mixing or cross contamination of hot side and cold side fluids. Gaskets shall be NBR. Channel plate carrying bars shall be stainless steel. Fixed frame plate and movable pressure plates shall be corrosion-resistant, epoxy-painted steel. Assembly bolts shall be steel. Piping connections 4 inch and larger shall be strudded port design to accept ANSI flange connections. Connection ports shall be integral to the frame or pressure port.
 2. Exchanger shall be ASME stamped for 150 psig working pressure at 225 deg. F. design temperature and shall be hydrostatically tested at one and one-half times full differential pressure. Exchanger shall fit allotted space and be sized for the scheduled capacity and shall conform to scheduled pressure drop maximums.
- C. Install a drain pan under each heat exchanger. Pan shall be of minimum 18 gauge, stainless steel with all joints watertight.
- D. Performance Data: See schedule on drawings.
- E. Manufacturer: Heat exchanger shall be by Bell & Gossett. Exchangers by Alfa Laval or Tranter, meeting the above specifications will be considered for approval.

2.17 GLYCOL SOLUTION AND PUMP PACKAGE

- A. General: Provide, where indicated, simplex automatic glycol solution make-up unit in the heat recovery (glycol) system in accordance with the following specifications. Units shall be a complete package with reservoir, pumps, motors, expansion tank and all associated controls. Unit shall be UL listed.
- B. Construction:
1. Reservoir: 55 gallon tank shall be industrial grade polyethylene suitable for a glycol solution. Reservoir shall be provided with a removable lid, visible solution level scale in gallons and liters, and top opening for fill and ventilation.
 2. Pump shall be provided with open dripproof motors and pump isolation.
 3. Package shall be factory-assembled to form an integral unit. Package shall include Y-strainer, triple duty valve, isolation valve, check and balance valve, diaphragm expansion tank, discharge pressure gauge, motor contactor, pressure control and all necessary interconnecting piping.
 4. Safeties include:
 - a. Low water cut off switch
 - b. Remote alarm contact
 - c. Red indicator light
 - d. Pressure switch/starter
- C. Controls: Pump shall be furnished with automatic controls. All wiring shall be copper. All wiring shall be factory-installed in accordance with the latest edition of the NEC.
- D. Performance Data: See schedule on drawings.
- E. Accessories include:
1. Factory-wired fused disconnect switch

2. NEMA 1 control panel enclosure

- F. Manufacturer: Equipment shall be by Bell & Gossett. Pumps by Armstrong, FLO FAB or Taco, meeting the above specifications will be considered for approval.

2.18 CHEMICAL FEEDERS

- A. Provide where indicated on the drawings for the heating water systems, American Water Conditioning, Inc., Model 12 HD, 12 gallon bypass pot type chemical feeders rated at a working pressure of 200 psi. Unit shall be complete with flow indicator, brass strainer 3/4 inch drain valve, 3/4 inch shutoff valve, brass needle valve, and brass air release cock. Shell and head shall be fabricated of 10 gauge steel with protective coating on both inside and outside surfaces. Similar equipment by Nalco or Chemtron Corporation will be acceptable.
- B. Water Treatment Chemicals: Supplier of treatment equipment shall perform analysis of water and supply chemicals for first year of system operation. Periodic water samples shall be obtained (a minimum of once per month) and analyzed as necessary to insure proper treatment through first year of operation. Supplier shall clean any water side surface that becomes sealed or biologically clogged. Equipment shall not be operated without treatment.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR HANDLING UNIT (MODULAR)

- A. Examination:
1. Examine areas and conditions to receive equipment for compliance with installation tolerances and other conditions affecting performance of central station, air handling units.
 2. Examine roughing-in of steam, hydronic, condensate drainage piping, and electrical to verify actual locations of connections before installation.
 3. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Installation:
1. Install central station, air handling units level and plumb according to manufacturer's written instructions.
 - a. Floor-Mounted Units: Set unit on concrete floor slab using neoprene pads. Secure units with anchor bolts to concrete floor slab.
 2. Arrange installation of units to provide access space around air handling units for service and maintenance.
- C. Connections:
1. Piping installation requirements are specified in specification Section 230600. The drawings indicate the general arrangement of piping, fittings and specialties. The following are specific connection requirements:
 - a. Install piping adjacent to machine to allow service and maintenance.
 - b. Connect condensate drain pans using Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
 - c. Hot and Chilled Water Piping: Conform to applicable requirements of specification Section 230600. Connect to supply, and return coil tapings with shutoff or balancing valve and union or flange at each connection.
 - d. Seal all pipe penetration openings airtight in unit housing.
 2. Duct installation and connection requirements are specified in specification Section 238800. The drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connections when fans within unit are not flex connected internally.

- a. Electrical: Conform to applicable requirements of Division 26 sections.
 - b. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
 - c. Temperature control wiring and interlock wiring are specified in specification Section 239500.
 - D. Demonstration: Engage the services of a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance. Schedule training with Owner through Architect with at least 7 days advance notice.
 - E. Examination: Examine ducts and units to receive air coils for compliance with requirements for installation tolerances and other conditions affecting performance of the air coils. Verify piping rough-in dimensions. Do not proceed with installation until unsatisfactory conditions have been corrected.
 - F. Installation:
 - 1. Install air coils and duct heaters as indicated, level and plumb, and according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.
 - 2. Install air coils and duct heaters in metal ducts and casings constructed according to SMACNA's HVAC Duct Construction Standards.
 - 3. Anchor air coils in position using suitable supports.
 - 4. Install piping connections, maintaining manufacturer's recommended clearances for service and maintenance of coils.
 - 5. Install shutoff valves at coil inlet and outlet connections.
 - G. Installation:
 - 1. Install filter frames according to manufacturer's written instructions.
 - 2. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
 - 3. Install filters in position to prevent passage of unfiltered air.
 - 4. Install filter gauge for each filter bank.
 - 5. Install filter gauge static pressure taps upstream and downstream from filters to measure pressure drop through filter. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.
 - 6. Coordinate filter installations with duct and air handling unit installations.
 - H. Field Quality Control:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components, filter and filter frame installation and electrical wiring. Report results in writing.
- 3.2 INSTALLATION OF MODULAR BOILER
- A. All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions. The vent system must conform to all manufacturer's recommendations and shall utilize UL listed stainless steel AL-29-4C Positive Pressure. The vent must be sized in accordance with manufacturer's recommendations. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance. Each boiler shall be provide with an individual supply gas regulator for proper gas regulation with a 2 inch NPT connection.

3.3 INSTALLATION OF LOW TEMPERATURE STACK

- A. Examination: Examine area of chimney installation for compliance with requirements for installation tolerances and other conditions that may affect proper installation. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Installation:
 - 1. Install stack and breeching level and plumb according to manufacturer's written instructions and referenced standards.
 - 2. Install chimney according to NFPA 54 and any additional local code requirements.
 - 3. Provide support(s) as required in accordance with manufacturer's guidelines.
 - 4. Maintain clearance to combustibles recommended by manufacturer.

3.4 INSTALLATION OF VARIABLE FREQUENCY DRIVES (VFD)

- A. VFD shall be mounted close to the motor in order to prevent transient voltage to add to the system voltage. The resulting voltage could be in excess of what can be tolerated by the motor winding insulation.
- B. Input power, output power and control circuits shall be run in separate metallic conduits.
- C. Loose mounted units shall be mounted with minimum of 6 inch of clearance on top, bottom and both sides for ventilation.
- D. Wiring of controllers shall be in strict accordance with manufacturer's installation instructions. Controllers shall not be energized without manufacturer's authorization.
- E. Verify motor and controller is properly grounded. Provide an independent equipment grounding conductor in the input power raceway.
- F. Provide initial startup adjustments under manufacturer's supervision.
- G. Verify that transducers are right type and are connected and adjusted in accordance with installation instructions.
- H. Control system electrical interlocks shall be checked for proper operation.
- I. Vacuum clean interior of controller.
- J. Copy of tests and checks performed in field with recordings shall be submitted to Architect/Engineer for record.
- K. Remote Motor Disconnects: All motor disconnect switches installed remote from the VFD shall have auxiliary contacts wired to the VFD. When the disconnect switch is opened the auxiliary contacts shall open and de-energize the VFD. This will prevent unintentional energizing of the motor on the VFD in other than a soft-start.

3.5 INSTALLATION OF DUCTLESS SPLIT COOLING SYSTEM

- A. Examination: Examine area for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.
 - 1. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.
 - 2. Verify that ceiling system is ready to receive work and opening dimensions are as indicated on shop drawings.
 - 3. Verify that power supply is available and of the correct characteristics.
- B. Installation:
 - 1. Install units according to manufacturer's written instructions.
 - 2. Install units level and plumb.
 - 3. Install air-cooled condensing unit on vibration isolation according to specification Section 232400.

C. Connections:

1. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings and specialties. The following are specific connection requirements:
 - a. Install piping to allow service and maintenance.
 - b. Drainage Connections: Conform to applicable requirements of specification Section 230600. Provide adequate connections for refrigeration circuits and condensate.
 - c. Refrigerant Piping: Conform to applicable requirements of the manufacturer.
2. Electrical: Conform to applicable requirements in Division 26 Sections.
3. Ground Equipment: Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

D. Demonstration: Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Schedule training with Owner, through Engineer, with at least 7 days advance notice.

3.6 INSTALLATION OF LABORATORY EXHAUST FANS (MIXED FLOW, INDUCED DILUTION TYPE)

A. Examination: Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the fans. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Installation:

1. Install fans level and plumb according to manufacturer's written instructions.
2. Secure roof-mounted fans to roof curbs with stainless steel hardware.
3. Install units with clearances for service and maintenance.
4. Label fans according to requirements specified in specification Section 231900.

C. Connections:

1. Duct installation and connection requirements are specified in specification Section 238800 and as directed by manufacturer. Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.
2. Electrical: Conform to applicable requirements in Division 26 sections.
3. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

D. Field Quality Control - Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of fans, including duct and electrical connections, alignment of fan shaft and motor shaft, alignment of pulleys, belt adjustments, and lubrication, and to report results in writing.

E. Demonstration:

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power exhaust fans.
 - a. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - b. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.7 INSTALLATION OF IN-LINE CENTRIFUGAL FANS

- A. Examination: Examine areas and conditions for compliance with requirements of installation tolerances and other conditions affecting performance of the power exhaust fans. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Installation:
 - 1. Install fans level and plumb according to manufacturer's written instructions.
 - 2. Support units using the vibration control devices indicated in specification Section 232400.
 - 3. Install units with clearances for service and maintenance.
 - 4. Label units according to requirements specified in specification Section 231900.
- C. Connections:
 - 1. Duct installation and connection requirements are specified in Division 23 Section 238800. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section 238800.
 - 2. Install ducts adjacent to fans to allow service and maintenance.
 - 3. Electrical: Conform to applicable requirements in Division 26 Sections.
 - 4. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- D. Field Quality Control - Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of fans, including duct and electrical connections, alignment of fan shaft and motor shaft, alignment of pulleys, belt adjustments, and lubrication, and to report results in writing.
- E. Demonstration:
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - 2. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.8 INSTALLATION OF CEILING-MOUNTED EXHAUST FAN

- A. Delivery, Storage and Handling:
 - 1. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
 - 2. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
 - 3. Lift and support units with manufacturer's designated lifting or supporting points.
- B. Examination: Examine areas and conditions for compliance with requirements of installation tolerances and other conditions affecting performance of the power exhaust fans. Do not proceed with installation until unsatisfactory conditions have been corrected.
- C. Coordination: Coordinate size and location of structural-steel support members.
- D. Installation:
 - 1. Install power exhaust fans level and plumb according to manufacturer's written instructions.
 - 2. Suspend units from structure; use steel wire or metal straps.
 - 3. Install units with clearances for service and maintenance.
 - 4. Label units according to requirements specified in Division 23 Section 231900.

E. Connections:

1. Duct installation and connection requirements are specified in Division 23 Section 238800. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section 238800.
2. Install ducts adjacent to power exhaust fans to allow service and maintenance.
3. Electrical: Conform to applicable requirements in Division 26 Sections.
4. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. Cleaning:

1. On completion of installation, internally clean fans according to manufacture's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and housing.
2. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.9 INSTALLATION OF CENTRIFUGAL UPBLAST ROOF EXHAUST FAN

A. Delivery, Storage and Handling:

1. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

B. Examination: Examine areas and conditions for compliance with requirements of installation tolerances and other conditions affecting performance of the power exhaust fans. Do not proceed with installation until unsatisfactory conditions have been corrected.

C. Coordination:

1. Coordinate size and location of structural-steel support members.
2. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories", Section 230500, and this section.

D. Installation:

1. Install power exhaust fans level and plumb according to manufacturer's written instructions.
2. Support units using the vibration control devices indicated in specification Section 232400.
3. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
4. Install units with clearances for service and maintenance.
5. Install grease exhaust fans to meet NFPA requirements of 40 inch minimum discharge above roof.
6. Label units according to requirements specified in specification Section 231900.

E. Connections:

1. Duct installation and connection requirements are specified in Division 23 Section 238800. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section 238800.
2. Install ducts adjacent to power exhaust fans to allow service and maintenance.
3. Electrical: Conform to applicable requirements in Division 26 Sections.

4. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. Field Quality Control:

1. Perform the following field tests and inspections and prepare test reports:
 - a. Verify that shipping, blocking, and bracing are removed.
 - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - c. Verify that cleaning and adjusting are complete.
 - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - e. Verify lubrication for bearings and other moving parts. Lubricate bearings if required.
 - f. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and confirm proper motor rotation and unit operation.
 - g. Shut unit down and reconnect automatic temperature-control operators.
 - h. Remove and replace malfunctioning units and controls and retest as specified above.

G. Adjusting:

1. Adjust damper linkages for proper damper operation.
2. Adjust belt tension.
3. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
4. Replace fan and motor pulleys as required to achieve design airflow.
5. Lubricate bearings.

H. Cleaning:

1. On completion of installation, internally clean fans according to manufacture's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and housing.
2. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

I. Demonstration:

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power exhaust fans.
 - a. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - b. Review data in maintenance manuals.
 - c. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.10 INSTALLATION OF PUMPS (IN-LINE)

A. Examination:

1. Examine areas, equipment foundations and conditions with Installer present for compliance with requirements for installation and other conditions affecting performance of pumps.
2. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

3. Do not proceed until unsatisfactory conditions have been corrected.

B. Installation:

1. Install pumps according to manufacturer's written installation and alignment instructions.
2. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.
3. Support pumps and piping separately so that piping is not supported by pumps.
4. Suspend in-line pumps using continuous thread hanger rod and vibration isolation hangers (in accordance with specification Section 232400) of sufficient size to support weight of pump independent of piping system.

C. Connections:

1. General: Install shutoff valve and strainer on pump suction and check valve and shutoff valve on pump discharge, except where other arrangement is indicated.
2. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.
3. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles.
4. Install check valve and throttling valve on discharge side of in-line circulators.
5. Install non-slam check valve and globe valve on discharge side of vertical in-line pumps.
6. Install suction diffuser and shutoff valve on suction side of base-mounted pumps.
7. Install triple-duty valve on discharge side of base-mounted pumps.
8. Install flexible connectors on suction and discharge sides of base-mounted pumps and where indicated.
9. Install thermometers where indicated.
10. Install pressure gauges on pump suction and discharge. Install at integral pressure gauge tapings where provided.
11. Install electrical connections for power, controls and devices.
12. Electrical power and control wiring and connections are specified in Division 26 Sections.

D. Field Quality Control:

1. Check suction piping connections for tightness to avoid drawing air into pumps.
2. Clean strainers.
3. Set pump controls.

3.11 INSTALLATION OF PROPELLER UNIT HEATERS

- A. Examination:** Examine substrates and supports to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Installation:

1. Install propeller unit heaters level and plumb according to manufacturer's written instructions.
2. Install unit heaters as indicated, according to manufacturer's written instructions and NFPA 90A.
3. Install units with clearances for service and maintenance.
4. Label unit heaters according to requirements specified in specification Section 231900.
5. Install wall-mounted thermostat.

C. Connections:

1. Connect unit heater and components to piping according to specification Section 230600.
2. Electrical: Conform to applicable requirements in Division 26 sections
3. Grounding: Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

3.12 INSTALLATION OF CABINET UNIT HEATERS

- A. Examination: Examine substrates and supports to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Installation:
 - 1. Install cabinet unit heaters level and plumb.
 - 2. Install cabinet unit heaters as indicated according to manufacturer's written instructions and NFPA 90A.
 - 3. Horizontal units shall be supported from structure above with threaded rods and vibration isolation. Vibration isolation shall be as specified in Section 232400.
- C. Connections:
 - 1. Connect cabinet unit heaters to hydronic piping according to specification Section 230600. Provide shutoff valve and union or flange at each connection.
 - 2. Electrical: Conform to applicable requirements in Division 26.
 - 3. Grounding: Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
 - 4. Install units and associated piping for service and maintenance.
 - 5. Install wall-mounted controls.

3.13 INSTALLATION OF FIN TUBE RADIATION

- A. Examination: Examine heating units for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Installation:
 - 1. Install finned tube radiation units level and plumb, according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.
 - a. Refer to Mechanical and Architectural Drawings for location of finned tube enclosure.
 - b. Position enclosure to allow for installation or removal of enclosure without damage to wall.
 - c. Align heating elements to prevent contact with brackets, wall or enclosure.
 - d. Install enclosure, mounting brackets channel, and manufacturer furnished trim, end caps and mitered corner pieces to provide continuous enclosure.
 - e. Unless otherwise noted, center heating element and enclosure under window.
 - f. Use methods and accessories to accommodate thermal expansion.
 - g. Install manufacturer's access section and access door for access to valves and other fittings.
 - h. Install air seal gasket between wall and enclosure mounting channel.
 - i. Terminate unit enclosures with manufacturer's end caps.
 - 2. Connect heating units and components to piping according to specification Section 230600.

3.14 INSTALLATION OF PLATE HEAT EXCHANGER

- A. Examination: Examine elements and surfaces to receive work for compliance with installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of the heat exchanger. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Installation:

1. Install heat exchangers according to manufacturer's written instructions.
2. Install heat exchangers plumb and level; anchor with supports.
3. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections maintaining clearances for service and maintenance of heat exchangers.
4. Install threaded or flanged connections at heat exchangers.
5. Install shutoff valves at heat exchanger inlet and outlet connections.

C. Demonstration:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Schedule training with Owner through Architect with at least 7 days advance notice.

3.15 INSTALLATION OF GLYCOL SOLUTION AND PUMP PACKAGE

A. Examination:

1. Examine areas, equipment foundations and conditions for compliance with requirements for installation and other conditions affecting performance of condensate return unit.
2. Examine roughing-in of piping systems to verify actual locations of piping and electrical connections before unit installation.
3. Do not proceed until unsatisfactory conditions have been corrected.

B. Installation:

1. Install glycol solution make-up unit according to manufacturer's written instructions.
2. Install units in locations indicated and arranged to provide access for periodic maintenance, including removal of motor, coupling and accessories.
3. Install units on concrete bases as indicated. Anchor units to bases using inserts or anchor bolts.
4. Install a full charge of a glycol solution in the chilled water system installed under this contract. Solution shall be 30 percent propylene glycol by volume.
5. Provide a white on red engraved laminated plastic sign (not less than 8 inch x 5 inch on the wall adjacent to the glycol pump package. Sign shall read as follows:

WARNING
DO NOT DRAIN
SYSTEM CONTAINS
GLYCOL SOLUTION

6. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

C. Connections:

1. Electrical power single point connection by Division 26 Contractor.
2. Control wiring shall be as specified in Section 239500.

3.16 INSTALLATION OF CHEMICAL FEEDERS

A. Installation:

1. Install treatment equipment level and plumb according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.
2. Install all piping injection fittings and valves necessary for conveyance of samples, chemicals, etc., for a complete and operative system.

- B. Connections:** Piping installation requirements are specified in Section 230600. The drawings indicate the general arrangement of piping, fittings and specialties. Install piping adjacent to equipment to allow servicing and maintenance.

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Webster University
Cannon Design Project No. 004561.01**

C. Cleaning:

1. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes including chips, scratches and abrasions.
2. Add cleaning chemicals as recommended by manufacturer.
3. Hot Water Heating System: Apply heat while circulating, slowly raising system to design temperature; maintain for a minimum of 12 hours. Remove heat and allow to cool; drain and refill with clean water. Circulate for 6 hours at design temperature, then drain. Refill with clean water and repeat until system cleaner is removed.

D. Demonstration:

1. Provide services of supplier's technical representative for half a day to instruct Owner's personnel in operation, maintenance and testing procedures.
2. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
3. Schedule training with Owner, through the Architect, with at least 7 days advance notice.

END OF SECTION 235000

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INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 238800 – AIR DISTRIBUTION

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	SUMMARY	1
1.3	SYSTEM DESCRIPTION	1
1.4	DEFINITIONS	2
1.5	SUBMITTALS	2
1.6	QUALITY ASSURANCE	3
1.7	LEED REQUIREMENTS	3
PART 2 - PRODUCTS		3
2.1	MANUFACTURERS	3
2.2	SHEET METAL MATERIALS	4
2.3	DUCT LINER	4
2.4	SEALANT MATERIALS	5
2.5	HANGERS AND SUPPORTS	5
2.6	RECTANGULAR DUCT FABRICATION	5
2.7	ROUND DUCT AND FITTING FABRICATION	6
2.8	DUCT ACCESSORIES	7
2.9	AIR DISTRIBUTION DEVICES	12
2.10	AIR TERMINAL UNITS	13
2.11	HVAC CASINGS	14
PART 3 - EXECUTION		17
3.1	DUCT APPLICATIONS	17
3.2	DUCT INSTALLATION	18
3.3	APPLICATION OF LINER IN RECTANGULAR DUCTS	18
3.4	INSTALLATION OF LINER IN RECTANGULAR DUCTS	19
3.5	APPLICATION AND INSTALLATION OF DUCT ACCESSORIES	20
3.6	INSTALLATION OF AIR DISTRIBUTION DEVICES	21
3.7	INSTALLATION OF AIR TERMINAL UNITS	22
3.8	INSTALLATION OF HVAC CASINGS	23
3.9	MANUFACTURED PRODUCTS	24
3.10	SEAM AND JOINT SEALING	24
3.11	HANGING, SUPPORTING AND BRACING	24
3.12	FRAMED OPENINGS AND SLEEVES	25
3.13	CONNECTIONS	25
3.14	FIELD QUALITY CONTROL	25
3.15	CLEANING NEW SYSTEMS	25

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SECTION 238800 - AIR DISTRIBUTION

PART 1 - GENERAL

1.1 REFERENCES

- A. Drawings and general provisions of the Contract, including GENERAL and SUPPLEMENTARY CONDITIONS and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes air distribution ductwork, accessories, devices, and equipment for supply, return, outside air, and exhaust air systems in pressure classes from minus 2 to plus 10 inch w.g. This section includes the following:
 - 1. Metal Ducts:
 - a. Rectangular ducts and fittings.
 - b. Single-wall, round, spiral-seam ducts and formed fittings.
 - c. Double-wall, round, spiral-seam ducts and formed fittings.
 - 2. Duct Lining.
 - 3. Duct Accessories and Sheet Metal Specialties:
 - a. Backdraft dampers.
 - b. Volume dampers.
 - c. Motorized control dampers.
 - d. Fire dampers.
 - e. Smoke dampers.
 - f. Combination fire and smoke dampers.
 - g. Sound attenuators.
 - h. Turning vanes.
 - i. Duct-mounting access doors.
 - j. Flexible connectors.
 - k. Spin-in connector.
 - l. Regulators.
 - m. Flexible ducts.
 - n. Duct accessory hardware.
 - 4. Air Devices: Ceiling, wall, and duct-mounted diffusers, registers, and grilles.
 - 5. Air Terminal Units: Single-duct air terminal units.
 - 6. HVAC casings for shop and field or factory-fabricated outside air plenum housing for central air handling equipment.
- B. Related sections include the following:
 - 1. Division 07 for roofing around roof curb.
 - 2. Division 10 for louvers provided as part of the general construction.
 - 3. Division 23 Section "Basic Mechanical Requirements" for general shop drawing requirements.
 - 4. Division 23 Section "HAC Equipment" for roof mounting exhaust fans and makeup air units.
 - 5. Division 23 Section "Controls and Instrumentation" for coordination with controls manufacturer for factory mounted control equipment, for electric damper actuators, exhaust fans, heaters, and fire alarm systems.
 - 6. Division 26 for duct mounting fire and smoke detectors.

1.3 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect/Engineer. Accompany

requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

- B. Sheet metal work shown on plans is schematic and is based on specified manufacturer's equipment and material dimensions. Make accurate measurements in field prior to ductwork fabrication and provide necessary offsets and transition pieces required to accommodate actual structural and equipment conditions and to accommodate coordination with work of other trades, at no additional cost.
- C. Unless otherwise indicated duct sizes shown on plans for low-pressure class plus or minus 2.0 inch w.g. are OUTSIDE DIMENSIONS; medium to high-pressure class 3.0 inch w.g. and higher duct sizes are INSIDE DIMENSIONS. Contractor need not increase duct size to allow for thickness of duct lining for low-pressure class systems.

1.4 DEFINITIONS

- A. Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section these values are expressed as Btu x in./h x sq. ft. x deg. F.
- B. Duct Pressure Class:
 - 1. Low-pressure (LP) class ductwork plus or minus 2.0 inch w.g., all ductwork shown on drawings without indication of pressure class shall be low-pressure class construction.
 - 2. Medium-pressure (MP) class ductwork 3.0 inch w.g. to 6.0 inch, whether labeled or not, ductwork from supply fan discharge to air terminal unit inlet shall be considered medium pressure.
- C. NUSIG: National Uniform Seismic Installation Guidelines.

1.5 SUBMITTALS

- A. Refer to Section 230100 BASIC MECHANICAL REQUIREMENTS for basic submittal requirements. The following are additional submittal requirements for specific devices and equipment specified in this section.
- B. Product Data: Refer to individual articles in PART 2 for additional requirements.
 - 1. Duct construction for each duct system. Using copies of SMACNA duct construction tables for each pressure class used, indicate proposed sheet metal gauge and reinforcement for listed duct sizes.
 - 2. Each type of Non-metal Ducts specified.
 - 3. Each type of Duct Accessories specified.
 - 4. Sound Attenuators: Indicate materials of construction, model number, certified performance data including dynamic insertion loss, self-noise power levels and pressure drop.
 - 5. Air Distribution Devices:
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Diffuser, Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. Refer to individual articles in PART 2 for additional requirements.
 - 1. Duct accessories, including access doors and panels. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Special fittings.
 - b. Manual-volume damper installations.

- c. Motorized-control damper installations.
 - d. Fire damper, smoke damper, and combination fire and smoke damper installations, including sleeves and duct-mounting access doors.
- 2. Air Distribution Devices: Contractor shall be responsible for the quantity takeoff and shall be required to submit a complete material takeoff tabulating all devices by room. Tabulation shall include room name or number, plan mark, type of device and accessories, neck and ceiling module size, number required, finish, airflow (cfm), face velocity, pressure drop, and NC rating.
- 3. Wiring Diagrams: Power, signal, and control wiring.
- D. Coordination Drawings: Refer to individual articles in Section 230100 - BASIC MECHANICAL REQUIREMENTS.
- E. Welding certificates.
- F. Field quality-control test reports.

1.6 QUALITY ASSURANCE

- A. Refer to individual articles in PART 2 for additional requirements.
- B. Sheet metal work shall be performed by Contractor's own sheet metal shop or be subcontracted to a qualified Sheet Metal Subcontractor. If a Subcontractor is used, name of Subcontractor shall be submitted to Architect/Engineer for approval prior to fabrication.
- C. Except as otherwise specified, quality of workmanship, metal gauges and construction details of sheet metal work shall comply with Sheet Metal & Air Conditioning Contractors National Association Inc. (herein referred to as SMACNA) publication entitled HVAC Duct Construction Standards Metal & Flexible latest edition.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
- E. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code-Steel," for hangers and supports.
- F. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- G. UL Compliance: UL listed and labeled as complying with UL 181, Class 1.

1.7 LEED REQUIREMENTS

- A. See Division 01 specifications, LEED REQUIREMENTS for requirements including but not limited to construction IAQ management plan.
- B. The VOC content of adhesives and sealants used must be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule #1168, AND all sealants used as fillers must meet or exceed the requirements of the Bay Area Quality Management District Regulation 8, Rule 51.
- C. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other PART 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Products: Subject to compliance with requirements, provide one of the products specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thickness, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view. Ductwork exposed in finished areas of building shall be fabricated of paint-grip galvanized steel conforming to latest ASTM Specification A-93.
- C. PVC-Coated Galvanized Steel: Acceptable by Authorities Having Jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653/A 653M and having G90 coating designation. Factory-applied PVC coatings shall be 4 mils thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 2 mils thick on opposite surfaces.
- D. Carbon Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- E. Stainless Steel: ASTM A 480/A 480M, Type 316, and having a No. 2D finish for concealed ducts and No. 4 for exposed ducts.
- F. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- G. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized sheet metal ducts.
- H. Tie Rods: Galvanized steel, 1/4 inch minimum diameter for lengths 36 inches or less; 3/8 inch minimum diameter for lengths longer than 36 inches.

2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 1. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thermal Conductivity (k-Value): 0.26 at 75 deg. F. mean temperature.
 - b. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - c. Liners shall be coated to prevent erosion and shall meet requirements ASTM C1071-00 and shall meet ASTM G21 and G22 test regarding fungal and bacterial growth.
 - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - 1) Tensile Strength: Indefinitely sustain a 50 pound tensile, dead-load test perpendicular to duct wall.
 - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire hazard classification of duct liner system.

2. Manufacturer: Equipment shall be by CertainTeed Corp.; Insulation Group. Equipment by Johns Manville International, Inc., Knauf Fiber Glass GmbH, or Owens Corning, meeting the above specifications will be considered for approval.

2.4 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Joint and Seam Tape: 2 inches wide, glass-fiber-reinforced fabric.
- C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Fasteners shall be approved by manufacturer for their intended loads.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 3. Galvanized steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- C. Anchors: Insert wedge type zinc-coated steel mechanical expansion anchors for use in concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 1. Supports for Galvanized Steel Ducts: Galvanized steel shapes and plates.
 2. Supports for Stainless Steel Ducts: Stainless steel support materials.
- F. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.6 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 - 1. Manufacturer: Equipment shall be by Ductmate Industries, Inc. Equipment by Nexus Inc. or Ward Industries, Inc., meeting the above specifications will be considered for approval.
- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," using corner, bolt, cleat, and gasket details.
 - 1. Duct Size: Maximum 30 inches wide and up to 2 inch w.g. pressure class.
 - 2. Longitudinal Seams: Pittsburgh lock sealed with non-curing polymer sealant.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of non-braced panel area unless ducts are lined.

2.7 ROUND DUCT AND FITTING FABRICATION

- A. Diameter as applied to ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of duct.
- B. Round, Longitudinal and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Longitudinal and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.
 - 1. Manufacturer: Ductwork shall be by McGill AirFlow Corporation. Ductwork by SEMCO Incorporated or shop fabricated ductwork meeting the above specifications will be considered for approval.
- D. Duct Joints:
 - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two (2) internal flanges with sealant and one external closure band with gasket.
 - 3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
 - 4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
 - a. Manufacturer: Ductwork shall be by Ductmate Industries, Inc. Ductwork by Lindab Inc., meeting the above specifications will be considered for approval.
- E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2 to plus 2 inch w.g.:

- a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
 - b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
 - c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2 to 10 inch w.g.:
 - a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
 - b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
 - c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
5. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45 and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate non-standard bend-angle configurations or non-standard diameter elbows with gored construction.
6. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate non-standard bend-angle configurations or non-standard diameter elbows with gored construction.
7. Round Elbows Larger Than 14 Inches in Diameter and All Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
8. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures: 0.040 inch thick with 2-piece welded construction.
9. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
10. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10 Inch w.g.: 0.022 inch.

2.8 DUCT ACCESSORIES

- A. Materials: Duct accessory material shall be as defined for sheet metal duct construction unless noted otherwise in this article.
- B. Backdraft Dampers:
 1. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6 inch width, with sealed edges, assembled in rattle-free manner with 90 degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
 2. Frame: 0.052 inch thick, galvanized sheet steel or 0.063 inch thick extruded aluminum, with welded corners and mounting flange.
 3. Blades: 0.025 inch thick, roll-formed aluminum.
 4. Blade Seals: Neoprene.
 5. Blade Axles: Nonferrous.
 6. Tie Bars and Brackets: Galvanized steel.
 7. Return Spring: Adjustable tension.
 8. Manufacturers: Equipment shall be by American Warming and Ventilating. Equipment by CESCO Products, Greenheck, Penn Ventilation Company, Inc., Prefco Products, Inc., or Ruskin Company, meeting the above specifications will be considered for approval.
- C. Volume Dampers:
 1. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

- a. Pressure Classes of 3 Inch w.g. or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
 2. Standard Volume Dampers: Multiple or single-blade, parallel or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - a. Steel Frames: Hat-shaped, galvanized or stainless sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - b. Roll-Formed Steel Blades: 0.064 inch thick, galvanized or stainless sheet steel.
 - c. Aluminum Frames: Hat-shaped, 0.10 inch thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - d. Roll-Formed Aluminum Blades: 0.10 inch thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050 inch thick extruded aluminum.
 - f. Blade Axles: Galvanized steel or Stainless steel.
 - g. Bearings: Oil-impregnated bronze or Stainless steel sleeve.
 - h. Tie Bars and Brackets: Galvanized steel or Aluminum.
 3. Low-Leakage Volume Dampers: Multiple or single-blade, parallel or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - a. Steel Frames: Hat or U-shaped, galvanized or stainless sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - b. Roll-Formed Steel Blades: 0.064 inch thick, galvanized or stainless sheet steel.
 - c. Aluminum Frames: Hat or U-shaped, 0.10 inch thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - d. Roll-Formed Aluminum Blades: 0.10 inch thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050 inch thick extruded aluminum.
 - f. Blade Axles: Galvanized steel or Stainless steel.
 - g. Bearings: Oil-impregnated bronze thrust or ball.
 - h. Blade Seals: Neoprene.
 - i. Jamb Seals: Cambered stainless steel.
 - j. Tie Bars and Brackets: Galvanized steel.
 4. Jackshaft: 1 inch diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - a. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
 5. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32 inch thick zinc-plated steel, and a 3/4 inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.
 6. Manufacturers: Equipment shall be by American Warming and Ventilating. Equipment by Flexmaster U.S.A., Inc., Nailor Industries Inc., Penn Ventilation Company, Inc., or Ruskin Company, meeting the above specifications will be considered for approval.
- D. Motorized Control Dampers: Dampers are specified under Section 239500. Install dampers in ductwork, mixed air plenums and in other indicated locations.

E. Spin-In Connectors:

1. Provide conical spin-in fittings with single-bladed volume control damper in takeoff collar at each flexible duct takeoff from main low-pressure class ducts to air distribution devices. Collars shall be similar to Flexmaster Type CB-D.
2. Spin-in Connectors: Provide spin-in fittings with single-bladed volume control damper in takeoff collar at each flexible duct takeoff from main low-pressure class ducts to air distribution devices. Collars shall be similar to Flexmaster Type FLD for sizes 8 inch and smaller and Type SLFD-B0 with Ventlok 641 handle and Ventlok 607 bearing for sizes larger than 8 inch. Regulator for Model SLFD-B0 shall be mounted on a built-out bracket to allow insulating of entire collar without obstructing operator handle.

F. Regulators:

1. Regulators for controlling dampers shall be extended to a point easily accessible. Regulators shall be the products of Young Regulator Co. or Ventlok according to the following schedule.

<u>Application</u>	<u>Cat. No. (Young)</u>	<u>Cat. No. (Ventlok)</u>
Exposed duct.....	No. 403B	No. 641
For volume damper on concealed ducts.....	No. 315	No. 677
Ducts above removable ceiling	No. 403B	No. 641

G. Fire Dampers:

1. Fire dampers shall be labeled according to UL 555.
2. Fire Rating: 1-1/2 or 3 hours.
3. Dampers shall be classified for dynamic closure to 2,000 fpm and 4 inches w.c. static pressure.
4. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034 inch thick galvanized steel; with mitered and interlocking corners.
5. Mounting Sleeve: Factory or field-installed galvanized sheet steel.
 - a. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
 - b. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, 0.034 inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034 inch thick, galvanized steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless steel closure spring.
9. Fusible Links: Replaceable, 212 deg. F. rated.
10. Manufacturer: Equipment shall be by Greenheck. Equipment by Nailor Industries Inc., Penn Ventilation Company, Inc., Prefco Products, Inc., Ruskin Company, or CESCO Products, meeting the above specifications will be considered for approval.

H. Smoke or Combination Fire and Smoke Dampers:

1. General Description: Labeled according to UL 555S, Class 1. Combination fire and smoke dampers shall be Class I rated and labeled according to UL 555 for 1-1/2-hour rating and dynamic closure to 2,000 fpm and 4 inch w.c. static pressure.
2. Fusible Links: Replaceable, 212 deg. F rated.
3. Frame and Blades: 0.064 inch thick, galvanized sheet steel.
4. Mounting Sleeve: Factory-installed, 0.052 inch thick, galvanized sheet steel; length to suit wall or floor application.
5. Damper Motors: Provide for modulating or two-position action.
 - a. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

- b. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - c. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg. F.
 - d. Non-Spring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - e. Electrical Connection: 115 volt, single phase, 60 Hertz.
 - 6. Manufacturers: Equipment shall be by Greenheck. Equipment by Nailor Industries Inc., Penn Ventilation Company, Inc., Ruskin Company, or CESCO Products, meeting the above specifications will be considered for approval.
- I. Sound Attenuators:
- 1. General Description: Factory-fabricated and tested, round or rectangular sound attenuators with performance characteristics and physical requirements as indicated.
 - 2. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.
 - 3. Rectangular Units: Fabricate casings with a minimum of 0.034 inch thick, solid galvanized sheet metal for outer casing and 0.022 inch thick, ASTM A 653/A 653M, G90, perforated galvanized sheet metal for inner casing.
 - 4. Round Units:
 - a. Outer Casings:
 - 1) ASTM A 653/A 653M, G90, galvanized sheet steel.
 - 2) Up to 24 Inches in Diameter: 0.034 inch thick.
 - 3) 26 through 40 Inches in Diameter: 0.040 inch thick.
 - 4) 42 through 52 Inches in Diameter: 0.052 inch thick.
 - 5) 54 through 60 Inches in Diameter: 0.064 inch thick.
 - 6) Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.
 - b. Interior Casing, Partitions, and Baffles:
 - 1) ASTM A 653/A 653M, G90, galvanized sheet steel.
 - 2) At least 0.034 inch thick and designed for minimum aerodynamic losses.
 - 5. Sheet Metal Perforations: 1/8 inch diameter for inner casing and baffle sheet metal.
 - 6. Fill Material: Inert and verminproof fibrous material, packed under not less than 5 percent compression.
 - a. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.
 - 7. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
 - a. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
 - b. Lock form and seal or continuously weld joints.
 - c. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - d. Reinforcement: Cross or trapeze angles for rigid suspension.
 - 8. Source Quality Control:
 - a. Acoustic Performance: Certified performance data derived from National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory tests in accordance with ASTM-E477.

- b. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with airflow of at least 2000 fpm face velocity.
 - c. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6 inch w.g. static pressure, whichever is greater.
 - 9. Manufacturers: Equipment shall be by Vibro-Acoustics. Equipment by Dynasonics, Transonics, or Semco, meeting the above specifications will be considered for approval.
- J. Turning Vanes:
 - 1. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows." Vane runners shall automatically align vanes.
 - 2. Vane Construction:
 - a. Vane lengths 36 inch and smaller: Shall be Single thickness vanes with 2 inch radius and 1.5 spacing.
 - b. Vane lengths larger than 36 inch: shall be double thickness vanes with 4.5 inch radius and 3.25-inch spacing.
 - 3. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 4. Manufacturers: Equipment shall be by Ductmate Industries, Inc. Equipment by Duro Dyne Corp., METALAIRE, Inc., SEMCO Incorporated, or Ward Industries, Inc.; a division of Hart & Cooley, Inc. meeting the above specifications will be considered for approval. Manufacturer's data shall be submitted for approval indicating pressure loss versus velocity in 90 degree elbows: Maximum loss at 2000 fpm shall be 0.10 inch w.c.
- K. Duct-Mounting Access Doors:
 - 1. General Description: Fabricate doors airtight and suitable for duct pressure class.
 - 2. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1 x 1 inch butt or piano hinge and cam latches. Access panels without hinges and installed 15 ft. above finished floor shall include a safety chain.
 - a. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - b. Provide number of hinges and locks as follows:
 - 1) Less Than 12 Inches Square: Secure with two (2) sash locks.
 - 2) Up to 18 Inches Square: Two (2) hinges and two (2) sash locks.
 - 3) Up to 24 by 48 Inches: Three (3) hinges and two (2) compression latches with outside and inside handle.
 - 4) Sizes 24 by 48 Inches and Larger: One additional hinge.
 - c. Manufacturers: Equipment shall be by American Warming and Ventilating. Equipment by Ductmate Industries, Inc., Flexmaster U.S.A., Inc., Greenheck, Nailor Industries Inc., Ventfabrics, Inc., or CESCO Products, meeting the above specifications will be considered for approval.
 - 3. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1 inch thickness. Include cam latches.
 - a. Frame: Galvanized sheet steel, with spin-in notched frame.
 - b. Manufacturers: Equipment shall be by Ductmate Industries, Inc. Equipment by Flexmaster U.S.A., Inc., meeting the above specifications will be considered for approval.
 - 4. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
 - 5. Insulation: 1 inch thick, fibrous-glass or polystyrene-foam board.

L. Flexible Connectors:

1. General Description: Flame-retardant or non-combustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two (2) strips of 2-3/4 inch wide, 0.028 inch thick, galvanized sheet steel or 0.032 inch thick aluminum sheets. Select metal compatible with ducts.
3. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - a. Minimum Weight: 26 oz./sq. yd.
 - b. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - c. Service Temperature: Minus 40 to plus 200 deg. F.
4. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - a. Minimum Weight: 24 oz./sq. yd.
 - b. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - c. Service Temperature: Minus 50 to plus 250 deg. F.
5. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - a. Minimum Weight: 14 oz./sq. yd.
 - b. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - c. Service Temperature: Minus 67 to plus 500 deg. F.
6. Manufacturers: Equipment shall be by Ductmate Industries, Inc. Equipment by Ventfabrics, Inc., meeting the above specifications will be considered for approval.

M. Flexible Ducts:

1. Non-Insulated-Duct Connectors: UL 181, Class 1, coated helically wound, spring-steel wire bonded to coated woven fiberglass cover.
 - a. Pressure Rating: 10 inch w.g. positive and 1.0 inch w.g. negative.
 - b. Maximum Air Velocity: 5000 fpm.
 - c. Temperature Range: Zero to 250 deg. F.
2. Insulated-Duct Connectors: UL 181, Class 1, coated helically wound, spring-steel wire bonded to inner duct of woven and coated fiberglass; fibrous-glass insulation; polyethylene vapor barrier film.
 - a. Pressure Rating: 10 inch w.g. positive and 1.0 inch w.g. negative.
 - b. Maximum Air Velocity: 5000 fpm.
 - c. Temperature Range: Minus 10 to plus 160 deg. F.
3. Flexible Duct Clamps: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches to suit duct size.
4. Manufacturers: Equipment shall be by Flexmaster U.S.A., Inc. Equipment by Thermaflex or Hart & Cooley, Inc., meeting the above specifications will be considered for approval.

N. Duct Accessory Hardware:

1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.9 AIR DISTRIBUTION DEVICES

A. General:

1. Provide air distribution devices, including grilles, registers and diffusers.

2. Types of air devices are indicated on the drawings. Verify ceiling construction to insure diffuser frame suitable for application before submission.
 3. Catalog numbers and finishes indicated in the schedule are for establishing a basis of quality and performance. These devices have been selected to be compatible with the architectural design and interior finishes. Contractor shall be required, if requested, to submit samples for each type of device to the Architect/Engineer for approval prior to the submission of shop drawings.
 4. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."
- B. Construction: Frames, blades and core elements shall be straight and true with mitered corners neatly joined and fastened to result in square joints without gaps. Blades and frames shall have hemmed edges to provide rigidity and to eliminate any waves in linear slots. Interior elements of slot-type diffusers shall have a flat black enamel finish. Exposed elements shall be primed and finished with baked or electroplated enamel. No primer shall be visible through finish coat, which shall be smooth and void of holidays. Volume dampers shall be opposed blade type with operator accessible from face of grille or diffuser. Damper shall fit tight to frame and shall be fitted with blades sufficiently tight to prevent rattles due to airflow. Frames shall be gasketed. Poorly constructed inferior quality air devices not meeting general industry standards will be rejected whether or not installed.
- C. Manufacturers: Equipment shall be by Titus. Equipment by Nailor Industries of Texas Inc., Price Industries, Tuttle and Bailey, or Krueger, meeting the above specifications will be considered for approval.

2.10 AIR TERMINAL UNITS

- A. Submittals:
1. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
 2. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
 3. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures", include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.
- B. Quality Assurance:
1. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Source Quality Control:
1. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
 2. Verification of Performance: Rate air terminal units according to ARI 880.
- D. Single-Duct Air Terminal Units:
1. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

2. Casing: 0.034 inch steel.
 - a. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - b. Air Outlet: S-slip and drive connections, size matching inlet size.
 - c. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance, with airtight gasket.
3. Lining for Unit Casing and Attenuator Section:
 - a. Lining material shall be odorless, verminproof and fire resistant. Liner and adhesive shall comply with the following codes:
 - 1) NFPA 255, UL 723 and ASTM E84 "Flame/Smoke Spread (25/50)"
 - 2) UL 181 "Air Erosion, Mold Growth and Humidity"
 - 3) NFPA 90A & 90B "Appliances"
 - 4) ASTM C665 "Corrosiveness"
 - 5) ASTM 1338, G21 and G22 "Fungi Resistance"
 - b. Casing Lining: 1 inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071 "Standard Specification for Fibrous Glass Duct Liner"; secured with adhesive. Cover liner with nonporous foil.
 - c. Casing Lining: Adhesive attached, 3/4 inch thick, Flexible Elastomeric Cellular Thermal Insulation complying with ASTM C534-03 "Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation"; secured with adhesive.
 - d. Liner edges at unit discharge or any raw edge shall be covered with metal nosing or foil. Use of adhesive or sealant is not acceptable.
4. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
 - a. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
 - b. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
5. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - a. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 6 inch w.g. inlet static pressure.
 - b. Damper Position: Normally open.
6. Attenuator Section: 0.034 inch steel sheet metal.
7. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
8. Velocity Sensor: Multipoint center averaging velocity sensor accurate to within 5 percent of set point while compensating for inlet static pressure variations up to 4 inch w.g.
9. DDC Controls: Single-package unitary controller and actuator specified in Division 23 Section 239500 - CONTROLS AND INSTRUMENTATION.
10. Manufacturers: Units shall be by Price Industries; Enviro-Air Division. Units by Krueger, Titus, Nailor Industries Inc., Environmental Technologies, Inc., Tuttle & Bailey, or Trane, meeting the above specifications will be considered for approval.

2.11 HVAC CASINGS

A. Submittals:

1. Product Data: For factory-fabricated casings, sealant materials, and acoustic liner materials.
2. Shop Drawings: Include plans, elevations, sections, components, and attachments to other work. Show fabrication and installation details of the following:

- a. Reinforcement and spacing.
 - b. Seam and joint construction.
 - c. Access doors, including frames, hinges, and latches.
 - d. Filter, coil, humidifier, and other apparatus.
 - e. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
 - f. Interior lighting, including switches.
3. Product Certificates: For factory-fabricated casings, signed by product manufacturer.
 - a. Show sound-absorption coefficients in each octave band lower than those scheduled when tested according to ASTM C 423.
 - b. Show airborne sound transmission losses lower than those scheduled when tested according to ASTM E 90.
- B. Coordination: Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 230500 and Division 03.
- C. Sheet Metal Materials:
 1. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
 2. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet steel casings.
 3. Tie Rods: Galvanized steel, 1/4 inch minimum diameter for lengths 36 inches or less; 3/8 inch minimum diameter for lengths longer than 36 inches.
 4. Miscellaneous Materials and Products: Types and sizes required to comply with HVAC casing system requirements, including proper connection of ducts and equipment.
- D. Duct Liner:
 1. Fibrous-Glass Liner: Comply with NFPA 90A and NAIMA AH124.
 - a. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - 1) Thickness: 2 inches.
 - 2) Thermal Conductivity (k-Value): 0.26 at 75 deg. F. mean temperature.
 - 3) Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
 - 4) Liner Adhesive: Comply with NFPA 90A and ASTM C 916.
 - 5) Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing leakage in casings.
 - a) Tensile Strength: Indefinitely sustain a 50 pounds tensile, dead-load test perpendicular to casing wall.
 - b) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - c) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
 - b. Manufacturers: Equipment shall be by CertainTeed Corporation; Insulation Group. Equipment by Johns Manville International, Inc., Knauf Fiber Glass GmbH., or Owens Corning, meeting the above specifications will be considered for approval.

E. Sealant Materials:

1. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
2. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
3. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

F. Shop and Field-Fabricated Casings:

1. Fabricate casings according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
2. Shop-fabricate casings, to greatest extent possible, with a minimum number of joints and to minimize field fabrication and assembly.
3. Fabricate casings with standing seams and angle reinforcements. Fabricate close-off sheets from casing sides, top, and bottom to damper, coil, and filter frames. Fabricate close-off sheets at joints between stacked coils. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.
4. Reinforce casings with galvanized or painted-steel angles.
5. Seal joints with liquid-type, high-pressure duct sealant to eliminate air leakage.
6. Fabricate drain pans for cooling coils, humidifiers, and eliminator blade sections in casings with external connections and vented deep-seal traps for drainage piping with 3/4 inch pipe connections. Fabricate and reinforce drain pans of same material and thickness as housing, 2 inches deep with rolled edges. Solder seams.
7. Fabricate casings with reinforced openings for access doors at least 24 inches wide by 48 inches high and located for access to each item of equipment housed. Refer to access doors this section.
8. Fabricate casings to receive flexible or outlet connectors for fans.
9. Static-Pressure Classifications: Unless otherwise indicated, fabricate HVAC casings for 2 inch w.g. pressure class.

G. Factory-Fabricated Casings:

1. Description: Double-wall, insulated, pressurized equipment casing.
 - a. Manufacturers: Equipment shall be by McGill AirFlow Corporation. Equipment by Semco, meeting the above specifications will be considered for approval.
2. Panel Fabrication: Solid, galvanized sheet steel exterior shell and solid, galvanized sheet steel interior shell; with 2 inch space between shells.
 - a. Fabricate with a minimum number of joints.
 - b. Weld exterior and interior shells to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
 - c. Exterior Shell Thickness: 0.040 inch minimum.
 - d. Interior Shell Thickness: 0.034 inch minimum.
 - e. Fabricate perimeter and interior, longitudinal channel members with galvanized steel shapes.
 - f. Fill each panel assembly with insulating material that is non-combustible, inert, mildew-resistant, and verminproof, and that complies with NFPA 90A.
 - g. Fabricate panels with tongue-and-groove, continuous self-locking joints effective inside and outside each panel.
3. Trim Items: Fabricate from a minimum of 0.052 inch galvanized sheet steel, furnished in standard lengths for field cutting.
4. Access Doors: Fabricate personnel access doors at least 24 by 60 inches and other access doors in sizes indicated.

- a. Fabricate doors of same thickness as panels, with a minimum 0.040 inch solid, interior and exterior, galvanized sheet steel shell.
 - b. Install a minimum of two (2) ball-bearing hinges and two (2) wedge-lever type latches, operable from inside and outside. Install doors to open against air pressure differential. Install neoprene gaskets around entire perimeters of doorframes.
 - c. Fabricate windows in doors consisting of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
5. Structural Performance: Fabricate plenum to be self-supporting and capable of withstanding internal static pressures as scheduled, without any panel joint exceeding deflection of $L/200$ where "L" is the unsupported span length within completed casings.
- a. Thermal Conductivity (k-Value): 0.26 at 75 deg. F. mean temperature.
6. Static-Pressure Classifications: Fabricate HVAC casings for 2 inch w.g. pressure class.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts (Low-Pressure LP): 2 inch w.g.
 2. Supply Ducts (before Air Terminal Units or Medium-Pressure MP): 4 inch w.g.
 3. Supply Ducts (after Air Terminal Units or Low-Pressure LP): 2 inch w.g.
 4. Return Ducts (Negative Pressure): 2 inch w.g.
 5. Exhaust Ducts (Negative Pressure): 2 inch w.g.
- B. All ducts shall be galvanized steel except as follows:
1. Range Hood Exhaust Ducts: Comply with NFPA 96.
 - a. Concealed: 16 gauge carbon-steel sheet or 14 gauge Type 304 stainless steel.
 - b. Exposed: Type 304, stainless steel with finish to match kitchen equipment and range hood.
 - c. Seams and joints shall be liquidtight externally welded and flange.
 - d. Duct shall slope towards hoods and be installed without forming dips or traps. An opening with access panel constructed of same material as duct and installed greasetight shall be provided at changes in direction and at regular intervals, minimum 20 ft., as required by NFPA Code. Openings shall be on side of duct and not less than 1-1/2 inch from bottom edge of duct.
 - e. Entire installation shall conform to requirements of NFPA Pamphlet No. 96.
 2. Laboratory Exhaust and Acid-Resistant (Fume-Handling) Ducts:
 - a. Ductwork from Fume Hoods to Exhaust Main: Type 304 stainless steel sheet with No. 4 finish. Seams and joints shall be liquidtight externally welded and flange.
 - b. Ductwork from general room exhaust and laboratory exhaust mains shall be G90 galvanized steel. Comply with the minimum code sheet metal thicknesses and SMACNA requirements.
 - c. Ductwork in Chemistry Lab Classroom 472 shall be constructed of a minimum 16 gauge thickness.
 - d. Turning vanes shall be fabricated of Type 304 stainless steel. Volume dampers shall have stainless steel bearings and shaft with epoxy-coated blades. Round dampers shall be Ruskin CDRS-25 less seals and rectangular dampers shall be Ruskin CD-35.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round ducts in lengths not less than 12 ft. unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of three (3) screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, fire and smoke-control dampers, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Through-Penetration Firestop Systems."
- O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and Section 232400.
- P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."
- Q. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized steel primer. Paint materials and application requirements are specified in Division 09 painting sections.

3.3 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Liner Thickness: Unless otherwise indicated, construct liner according to the following:
 - 1. Supply Ducts (Low-Pressure LP): 1 inch.
 - 2. Supply Ducts (before Air Terminal Units or Medium-Pressure MP): No liner.
 - 3. Supply Ducts (after Air Terminal Units or Low-Pressure LP): 1 inch.
 - 4. Return Ducts: 1 inch.
 - 5. Transfer Ducts: 1 inch.

6. Relief Ducts: 1 inch.
 7. General Exhaust Ducts: 1 inch. Main vertical exhaust risers need not be insulated.
 8. Outside Air Ducts and Plenums: 1 inch, except where directly connected to outside air louver. Where connected to louver, duct will be externally insulated for a distance 5 ft.-0 inch from louver. Remainder shall be lined as listed.
 9. Mixed Air and Prefilter Plenums: 1 inch.
- B. Duct lining shall be installed in strict accordance with latest edition of SMACNA's manual entitled "Duct Liner Application Standard." Liner shall be applied with mat facing toward airstream. Fasteners shall meet "Standards for Mechanical Fasteners MF-1-1975."
- C. Adhesive shall be applied to sheet metal with 100 percent coverage. Exposed edges of duct liner shall be coated with approved adhesive designed for duct liner application.
- D. Internal duct areas shall be completely covered with duct liner. Transverse joints shall be firmly butted with no gaps, and coated with adhesive. Rips and tears on airstream surface shall be repaired by coating damaged area with approved duct liner adhesive.
- E. Mechanical fasteners shall be used to additionally secure duct liner to sheet metal, and spaced in accordance with SMACNA's "Duct Liner Application Standard." Mechanical fasteners shall not compress insulation more than 1/4 inch for 1 inch liner, or more than 1/8 inch for 1/2 inch liner, and shall be installed perpendicular to duct surface.
- F. Longitudinal corner joints shall be overlapped and compressed.
- 3.4 INSTALLATION OF LINER IN RECTANGULAR DUCTS
- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
1. Fan discharges.
 2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
- I. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
1. Sheet Metal Inner Duct Perforations: 3/32 inch diameter, with an overall open area of 23 percent.

- J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

3.5 APPLICATION AND INSTALLATION OF DUCT ACCESSORIES

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized steel and stainless steel accessories in stainless steel ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside or where indicated.
- D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install dampers a minimum of two (2) duct widths from branch takeoff connection.
- F. Provide test holes at fan inlets and outlets and elsewhere as directed by Testing And Balancing (TAB) Contractor.
- G. Install fire, smoke and combination fire/smoke dampers, with fusible links, according to manufacturer's UL approved written instructions.
- H. Install duct silencers rigidly to ducts.
- I. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Downstream from volume dampers, turning vanes, and equipment.
 - 3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
 - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50 ft. spacing.
 - 5. On sides of ducts where adequate clearance is available.
- J. Install the following sizes for duct-mounting, rectangular access doors:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body Plus Ladder Access: 25 by 17 inches.
- K. Install the following sizes for duct-mounting, round access doors:
 - 1. One-Hand or Inspection Access: 8 inches in diameter.
 - 2. Two-Hand Access: 10 inches in diameter.
 - 3. Head and Hand Access: 12 inches in diameter.
 - 4. Head and Shoulders Access: 18 inches in diameter.
 - 5. Body Access: 24 inches in diameter.
- L. Install the following sizes for duct-mounting, pressure relief access doors:
 - 1. One-Hand or Inspection Access: 7 inches in diameter.
 - 2. Two-Hand Access: 10 inches in diameter.
 - 3. Head and Hand Access: 13 inches in diameter.
 - 4. Head and Shoulders Access: 19 inches in diameter.
- M. Label access doors according to Division 23 Section "Mechanical Identification."

- N. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- O. For fans developing static pressures of 5 inch w.g. and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- P. Connect terminal units to supply ducts with maximum 24 inch lengths of flexible duct. Do not use flexible ducts to change directions.
- Q. Connect diffusers to low pressure ducts with maximum 96 inch lengths of flexible duct clamped or strapped in place.
- R. Connect flexible ducts to metal ducts with draw bands and adhesive plus sheet metal screws.
- S. Flexible duct shall be installed by sliding duct over sheet metal sleeve to approximately one-half length of sleeve. Wrap 2 inch duct tape twice around duct plus one-quarter-turn overlap. Install clamping strap between last spiral of flexible duct. Slide insulation up to trunk duct and secure with duct tape so that sheet metal surfaces are covered.
- T. Flexible duct passing through partitions shall be provided with sheet metal sleeve at partition penetration. Duct shall be attached to sleeve with mastic and clamping strap on both sides of partition.
- U. Flexible duct shall only be installed above accessible ceilings. Ducts above inaccessible ceilings shall be constructed of sheet metal.
- V. Test Openings:
 - 1. Install duct test holes where indicated and required for testing and balancing purposes.
 - 2. Test openings shall be provided at supply zones or branch ducts and in main return ducts for determining air velocity or pressure during balancing and testing of systems.
 - 3. Test openings shall be plugged after balancing with plastic plugs specifically made for this purpose.
- W. Adjusting:
 - 1. Adjust duct accessories for proper settings.
 - 2. Adjust fire and smoke dampers for proper action.
- X. Final positioning of manual-volume dampers is specified in Division 23 Section TESTING, ADJUSTING, AND BALANCING.

3.6 INSTALLATION OF AIR DISTRIBUTION DEVICES

- A. Examination:
 - 1. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
 - 2. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation:
 - 1. Install diffusers, registers, and grilles level and plumb.
 - 2. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
 - 3. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
- C. Adjusting: After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.7 INSTALLATION OF AIR TERMINAL UNITS

A. General:

1. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
2. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Connections:

1. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to air terminal units to allow service and maintenance.
3. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
4. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding."
5. Connect wiring according to Division 26 Section "Conductors and Cables."
6. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

C. Field Quality Control:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
 - a. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service:

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - 1) Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 2) Verify that controls and control enclosure are accessible.
 - 3) Verify that control connections are complete.
 - 4) Verify that nameplate and identification tag are visible.
 - 5) Verify that controls respond to inputs as specified.

E. Demonstration: Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division 01 Section "Closeout Procedures".

F. Connections: Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

- G. Adjusting: Adjust damper linkages for proper damper operation.

3.8 INSTALLATION OF HVAC CASINGS

A. Examination:

1. Examine concrete bases and roof curbs for compliance with requirements for conditions affecting installation and performance of HVAC casings.
2. Proceed with installation only after unsatisfactory conditions have been corrected.
3. Installation: Install casings according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply with recommended spacing of sheet metal screws and with requirements for casing sealing and trim positioning.
4. Apply sealant to joints, connections, and mountings.
5. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
6. Support casings on floor or foundation system. Secure and seal to base.
7. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.
8. Align casings accurately at connections, with 1/8 inch misalignment tolerance and with smooth interior surfaces.
9. Maintain duct seal class integrity throughout casings.

B. Liner Installation:

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to liner that faces direction of airflow not receiving metal nosing.
3. Butt transverse joints without gaps and coat joint with adhesive.
4. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner with longitudinal joints, except at corners of casings, unless casing size and standard liner product dimensions make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in casings.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profile or are integrally formed from casing wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined casing preceding unlined casing.
 - c. Upstream edges of transverse joints in casings.

C. Field Quality Control:

1. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 - a. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - b. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
 - c. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.9 MANUFACTURED PRODUCTS

- A. Manufactured products shall be installed in accordance with manufacturers printed instructions.

3.10 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
 - 1. For pressure classes lower than 2 inch w.g., seal transverse joints.
- B. Seal ducts before external insulation is applied.

3.11 HANGING, SUPPORTING AND BRACING

- A. Ducts having a depth or width in excess of 30 inch shall be supported by angles or channels and threaded hanger rods. Smaller ducts may be supported with band type hangers with maximum hanger length above duct of 36 inch. Where more length is required, use rods in accordance with SMACNA requirements.
- B. Hanging ductwork from cables is not acceptable unless pre-approval is granted in writing by the Code Authorities Having Jurisdiction. Contractor shall submit copies of letters from Code Authority Having Jurisdiction prior to installation of cable type duct supports. Any calculations required for approval are the responsibility of Contractor.
- C. Ducts shall be hung independent of other elements and attached to structural framing members and concrete slabs as applicable. Ductwork and related equipment shall not be supported from electrical conduit or busways or from piping systems.
- D. Supports shall not be anchored to metal decking unless a means is provided to prevent puncturing the decking. Where supports are required between structural members, suitable intermediate metal framing shall be provided.
- E. Ductwork shall be reinforced and shall be crossbroken to prevent buckling, breathing and vibration. Beading may be used in lieu of crossbreaking at contractor's option.
- F. Medium and high-pressure class, 3 inch w.c. and higher, supply air ducts within mechanical rooms shall be supported by vibration isolation hangers. Vibration isolation hangers shall be double-in-shear neoprene type, Mason HD or approved equal with a minimum static deflection of 0.35 inch under load.
- G. Ducts shall be braced for withstanding seismic forces, see Section 232400.
- H. Ducts shall be properly supported at intervals recommended by SMACNA.
 - 1. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
 - 2. Support vertical ducts at maximum intervals of 16 ft. and at each floor. Vertical duct risers extending from floor to floor shall be anchored in a manner to allow movement due to thermal expansion.
- I. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- J. Install concrete inserts before placing concrete.
- K. Supports and hangers shall be supported from structural members, slabs and walls with pull-out, tension and shear capacities appropriate for supported loads and building structure where used.
- L. Install anchors where required in concrete construction. Install insert mechanical anchors in accordance with manufacturer's written instructions.
- M. Outdoor, Indoor Wet Locations, or Corrosive Environments: Materials for supports and fastening shall be hot-dipped galvanized after fabrication or stainless steel unless otherwise indicated.

3.12 FRAMED OPENINGS AND SLEEVES

- A. Space between openings and ductwork shall be sealed with sealant as called for in Section 230500 - BASIC MECHANICAL MATERIALS AND METHODS.

3.13 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 23 Section 238800, "Duct Accessories" article.
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.14 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 1. Testing shall be performed prior to covering ducts with insulation and prior to closing in ducts with building construction.
 2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 3. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give 7 days advance notice for testing.
 4. Maximum Allowable Leakage:
 - a. Comply with requirements for Leakage Class 3 for round ducts
 - b. Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2 inch w.g. (both positive and negative pressures), or 18.8 cfm per 100 sq. ft. of duct surface at 2 inch w.g. static pressure as verified by the air balance procedure.
 - c. Leakage Class 6 for pressure classes from 2 to 10 inch w.g., including plenums and shop or field fabricated air handling unit sections shall be tested at the pressure corresponding to the specified pressure class of the system. SMACNA leakage class for systems of various static pressure classifications shall not exceed the values in the following table:

<u>Duct Construction Class</u>	<u>*Leakage Class cfm/100 sq. ft.</u>
10 inch w.g.	26.8
6 inch w.g.	19.2
4 inch w.g.	14.8
3 inch w.g.	12.2

* Leakage is expressed in cfm per 100 sq. ft. of duct surface.

- 5. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.15 CLEANING NEW SYSTEMS

- A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- B. Use service openings, as required, for physical and mechanical entry and for inspection.
 1. Create other openings to comply with duct standards.
 2. Disconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling sections to gain access during the cleaning process.

- C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- D. Clean the following metal duct systems by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
 - 5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
- F. Cleanliness Verification:
 - 1. Visually inspect metal ducts for contaminants.
 - 2. Where contaminants are discovered, re-clean and reinspect ducts.

END OF SECTION 238800

INDEX

DIVISION 23 - MECHANICAL WORK

SECTION 239500 - CONTROLS AND INSTRUMENTATION

Article	Title	Page
PART 1 - GENERAL		1
1.1	RELATED DOCUMENTS	1
1.2	SUMMARY	1
1.3	DEFINITIONS	1
1.4	SUBSTITUTIONS	1
1.5	SUBMITTALS	1
1.6	QUALITY ASSURANCE	2
1.7	DELIVERY, STORAGE AND HANDLING	2
1.8	COORDINATION	3
1.9	ELECTRICAL WORK FOR CONTROLS	3
PART 2 - PRODUCTS		4
2.1	SYSTEM DESCRIPTION AND PERFORMANCE	4
2.2	MANUFACTURERS	5
2.3	DDC EQUIPMENT	5
2.4	CONTROL/ALARM PANELS	7
2.5	SENSORS	7
2.6	ACTUATORS	9
2.7	FLOW MEASUREMENT	10
2.8	CONTROL VALVES	11
2.9	DAMPERS	11
2.10	LABORATORY AIR VALVES/FUME HOOD CONTROLS	12
2.11	SMOKE DETECTORS	13
2.12	CONTROL CABLE	13
PART 3 - EXECUTION		13
3.1	EXAMINATION	13
3.2	INSTALLATION	13
3.3	ELECTRICAL WIRING AND CONNECTION INSTALLATION	14
3.4	CONNECTIONS	15
3.5	FIELD QUALITY CONTROL	15
3.6	ADJUSTING	16
3.7	DEMONSTRATION	17
3.8	ON-SITE ASSISTANCE	17
3.9	SEQUENCE OF OPERATION	17
3.10	FIRE-SMOKE DAMPERS	45
3.11	MONITORING AND ALARM OF VARIOUS SYSTEMS	45

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SECTION 239500 - CONTROLS AND INSTRUMENTATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to this Section.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Related Sections include the following:
 - 1. Section 235000 - HAC EQUIPMENT, for control equipment and devices provided by equipment manufacturers.
 - 2. Section 265700 - LIGHTING CONTROL EQUIPMENT, for building lighting control system.
 - 3. Section 267100 - FIRE ALARM SYSTEMS, for fire and smoke detectors mounted in HVAC systems and equipment.

1.3 DEFINITIONS

- A. DDC: Direct Digital Control.
- B. I/O: Input/Output.
- C. MS/TP: Master-slave/token-passing.
- D. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- E. PC: Personal Computer.
- F. PID: Proportional plus Integral plus Derivative.
- G. RTD: Resistance Temperature Detector.
- H. BAS: Building Automation System.

1.4 SUBSTITUTIONS

- A. No substitutions will be allowed except as specified in Section 230100 - BASIC MECHANICAL REQUIREMENTS.

1.5 SUBMITTALS

- A. Submittals for HVAC Instrumentation and Control work shall be submitted in accordance with the requirements described in Section 230100 - BASIC MECHANICAL REQUIREMENTS.
- B. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Label each control device with setting or adjustable range of control.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Provide the following:

1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices. Note whether devices are direct-acting, reverse-acting, fail-open, fail-closed, fail-last-position, 2-position, modulating, etc.
 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 3. Details of control panel faces, including controls, instruments, and labeling. Include layout and construction details of control panels specified.
 4. Written description of sequence of operation.
 5. Schedule of dampers including sizes, leakage, and flow characteristics.
 6. Schedule of valves including leakage and flow characteristics.
 7. Bill of materials of equipment indicating quantity, manufacturer and model number.
 8. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 9. Listing of connected data points, including connected control unit and input device. Include identification of functions that can be changed or adjusted from graphics screen such as on/off/auto, set point adjustment, alarm limits, control limits, etc.
 10. Provide listing of alarm points and priority settings. Indicate if alarm(s) annunciate at a pager or other third party system.
 11. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
 12. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- D. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- E. Software Upgrade Kit: Submit upgrade kit for Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.
- F. Field Quality-Control Test Reports: Indicate and interpret test results for compliance with performance requirements.
- G. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.
- 1.6 QUALITY ASSURANCE
- A. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
 - B. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
 - C. Comply with ASHRAE 135 for DDC system control components.
- 1.7 DELIVERY, STORAGE AND HANDLING
- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.
 - B. System Software: Update to latest version of software at Project completion.

1.8 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- C. Coordinate equipment with Division 26 Section 264000 - SERVICE AND DISTRIBUTION (TO 600 VOLTS) to achieve compatibility with panelboard starter coils and annunciation devices.
- D. Coordinate equipment with Division 26 Section 264000 - SERVICE AND DISTRIBUTION (TO 600 VOLTS) to achieve compatibility with motor control center motor starters and annunciation devices.
- E. Coordinate equipment with Division 26 Section 265700 - NETWORK LIGHTING CONTROLS to achieve compatibility with equipment that interfaces with that system.
- F. Coordinate equipment with Division 26 Section 267100 - FIRE ALARM SYSTEMS to achieve compatibility with equipment that interfaces with the fire alarm system.

1.9 ELECTRICAL WORK FOR CONTROLS

- A. For unit responsibility, all electrical work for HVAC Instrumentation and Controls shall be included in the Contractor's work.
- B. The Contractor shall be responsible for furnishing and installing all electrical work required for HVAC Instrumentation and Controls.
- C. Electrical work shall in general include all low voltage and line voltage work required for control devices specified in this section. All electrical work shall be installed in accordance with the NEC and shall conform with the following specified requirements:
 - 1. Rigid conduit shall be hot-dipped or electro-galvanized steel and shall conform to NEC. Rigid conduit shall have couplings and fittings of threaded galvanized steel and shall be provided with bushings at panels. Rigid conduit shall be used for the following applications:
 - a. All underground work (concrete encased)
 - b. All work exposed to weather
 - c. All work within or under concrete slabs (concrete encased)
 - d. Work in mechanical rooms, electrical rooms, loading docks, and other areas where conduit may be exposed to possible damage from the floor to a point 8 ft. above floor.
 - 2. PVC conduit shall be used for all direct-burial underground applications. Refer to Division 26 specifications for requirements.
 - 3. EMT shall be hot-dipped or electro-galvanized electrical metallic tubing conforming with NEC Paragraph 348. EMT couplings and fittings shall be compression type and bushings shall be provided at panels. EMT shall be used for all applications except as indicated above for rigid conduit and except where cable is installed in accessible ceiling plenums. "Plenum Rated" cable shall be used in the plenum space above accessible ceilings; plenum rated cable shall be secured to the structure using "Bridle Rings" and shall not be laid on top of ceiling or be supported from the work of other trades.
 - 4. All wiring and conduit shall be concealed in finished rooms. All wiring shall be copper and all wiring both exposed and concealed, except "Plenum rated" cable installed above accessible ceilings, shall be installed in conduit as defined above. No control wiring or automation cable will be allowed in power conduit or other conduit used for fire alarm, signaling, etc.
 - 5. All conduit connections to mechanical equipment shall be made with flexible conduit. Maximum flex conduit length shall not exceed 2 ft.-0 inch. Where exposed to weather, flexible conduit shall have a neoprene jacket. Where equipment is resiliently mounted, flexible conduit shall be at least 20 diameters in length.

6. All safety devices and all safety interlocks (freezestats, firestats, smoke detectors, end switches, etc.) shall be wired through motor starters and into variable frequency drive circuitry to prevent operation if any device is open under any condition. (Hand position of hand-off-automatic type switches shall not bypass safety devices.) The Owner shall be capable of energizing equipment in the "hand" position of a hand-off-auto type switch in the event of a failure of the controller, unless safety interlocks prevent such operation.
- D. The Contractor shall be responsible for coordinating with the Electrical Contractor the installation for emergency power for controllers that require 24 hour power.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION AND PERFORMANCE

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multi-user, multitasking environment on token-passing network and programmed to control mechanical systems.
- B. Control system includes the following:
 1. Building lighting control system specified in Section 265700 - NETWORK LIGHTING CONTROLS.
 2. Fire alarm system specified in Section 267100 - FIRE ALARM SYSTEMS.
- C. Comply with the following performance requirements:
 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within 5 seconds of each other.
 6. Program Execution Frequency: Run capability of applications as often as 5 seconds, but selected consistent with mechanical process under control.
 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 1 deg. F.
 - b. Water Flow: Plus or minus 5 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 1 deg. F.
 - e. Ducted Air Temperature: Plus or minus 1 deg. F.
 - f. Outside Air Temperature: Plus or minus 2 deg. F.
 - g. Dew Point Temperature: Plus or minus 3 deg. F.
 - h. Temperature Differential: Plus or minus 0.25 deg. F.
 - i. Relative Humidity: Plus or minus 5 percent.
 - j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
 - k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - l. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - m. Air Pressure (Space): Plus or minus 0.01-inch w.g.
 - n. Air Pressure (Ducts): Plus or minus 0.1-inch w.g.
 - o. Carbon Monoxide: Plus or minus 5 percent of reading.
 - p. Carbon Dioxide: Plus or minus 50 ppm.

- q. Electrical: Plus or minus 5 percent of reading.

2.2 MANUFACTURERS

- A. Building Automation System (BAS) shall be an extension of the campus automation system, Automated Logic, Inc. by Automatic Controls Equipment Systems, Inc. (314)722-2727.

2.3 DDC EQUIPMENT

A. Application Software:

1. I/O capability from operator station.
2. System security for each operator via software password and access levels.
3. Automatic system diagnostics; monitor system and report failures.
4. Database creation and support.
5. Automatic and manual database save and restore.
6. Dynamic color graphic displays with up to ten (10) screen displays at once.
7. Custom graphics generation and graphics library of HVAC equipment and symbols.
8. Alarm processing, messages, and reactions.
9. Trend logs retrievable in spreadsheets and database programs.
10. Alarm and event processing.
11. Object and property status and control.
12. Automatic restart of field equipment on restoration of power.
13. Data collection, reports, and logs. Include standard reports for the following:
 - a. Current values of all objects.
 - b. Current alarm summary.
 - c. Disabled objects.
 - d. Alarm lockout objects.
 - e. Logs.
14. Custom report development.
15. Utility and weather reports.

B. Custom Application Software:

1. English language oriented.
2. Full-screen character editor/programming environment.
3. Allow development of independently executing program modules with debugging/simulation capability.
4. Support conditional statements.
5. Support floating-point arithmetic with mathematic functions.
6. Contains predefined time variables.

C. Control Units: Provide modular, comprising processor board with programmable, non-volatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units shall monitor or control each input/output point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator station or PPT.
2. Standalone mode control functions shall operate regardless of network status. Functions include the following:
 - a. Global communications
 - b. Discrete/digital, analog, and pulse input/output
 - c. Monitoring, controlling, or addressing data points
 - d. Software applications, scheduling and alarm processing
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment

3. Standard Application Programs:
 - a. Units of Measure: IP (inch-pound) and SI (metric)
 - b. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, DDC with fine tuning, and trend logging.
 - c. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
 - d. Chiller Control Programs: Control function of condenser water reset, chilled-water reset, and equipment sequencing.
 - e. Programming Application Features: Include trend point, alarm messages, weekly scheduling, and interlocking.
4. Local operator interface shall provide for download from or upload to mobile operator station.
- D. Local Control Units: Provide modular, comprising processor board with electronically programmable, non-volatile, read-only memory, and backup power source.
 1. Units shall monitor or control each input/output point; process information; and download from or upload to operator station.
 2. Standalone mode control functions shall operate regardless of network status. Functions include the following:
 - a. Global communications
 - b. Discrete/digital, analog, and pulse input/output
 - c. Monitoring, controlling, or addressing data points
 3. Local operator interface shall provide for download from or upload to mobile operator station.
- E. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
 1. Binary Inputs: Allow monitoring of on/off signals without external power.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 3. Analog Inputs: Allow monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals.
 4. Binary Outputs: Provide on/off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 5. Analog Outputs: Provide modulating signal, either low voltage (0 to 10 VDC) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 6. Tri-State Outputs: Provide two (2) coordinated binary outputs for control of three-point, floating-type electronic actuators.
 7. Universal I/Os: Provide software selectable binary or analog outputs.
- F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
 1. Output ripple of 5.0 mV maximum peak to peak.
 2. Combined 1 percent line and load regulation with 100 mic.sec. response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- G. Power Line Filtering: Internal or external Surge Protective Device (SPD) for workstations or controllers with the following:
 1. Minimum dielectric strength of 1000 V.
 2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 CONTROL/ALARM PANELS

- A. Central (Master) Control Panels: Provide fully enclosed, steel rack type cabinet with locking doors or locking removable backs. Match finish of panels and provide multicolor graphic displays, schematically showing system being controlled.
- B. Local Control Panels: Provide unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.
 1. Fabricate panels of 0.06 inch thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
 2. Panel-Mounted Equipment: Provide temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.
 3. Door-Mounted Equipment: Provide flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gauges.
 4. Graphics: Provide color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.5 SENSORS

- A. Electronic Sensors: Vibration and corrosion resistant, for wall, immersion, or duct mounting as required.
 1. Resistance Temperature Detectors and Transmitters:
 - a. Accuracy: Plus or minus 0.2 percent at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - c. Insertion Elements in Ducts: Single point, length as required; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
 - d. Averaging Elements in Ducts: 18 inch long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft., length as required.
 - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inch.
 - f. Room Sensors:
 - 1) Standard manufacturer cover.
 - 2) Digital temperature display for actual space temperature and set point.
 - 3) Local set point adjustment, numerical, limited range programmable from BAS.
 - 4) Off-hours override to occupied mode with integral button or switch, duration programmable from BAS.
 - 5) Security through password protection or ability to deactivate local set point control from BAS required.
 - 6) Laptop or portable operator's tool communication jack that can be accessed without removing the cover.
 - g. Outside Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 - h. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.
 2. Humidity Sensors: Bulk polymer sensor element.
 - a. Accuracy: 5 percent full range with linear output.
 - b. Room Sensors: With locking cover matching room thermostats, span of 25 to 90 percent relative humidity.

- c. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
 - 3. Static Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent
 - b. Output: 4 to 20 mA
 - c. Building Static Pressure Range: 0 to 0.25 inch w.g.
 - d. Duct Static Pressure Range: 0 to 5 inch w.g.
 - 4. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- B. Pressure Transmitters/Transducers:
- 1. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0 to 0.25 inch w.g.
 - d. Duct Static-Pressure Range: 0 to 5 inch w.g.
 - 2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150 psig operating pressure; linear output 4 to 20 mA.
 - 3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150 psig operating pressure and tested to 300 psig; linear output 4 to 20 mA.
 - 4. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
- C. Equipment operation sensors as follows:
- 1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inch w.g.
 - 2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig
 - 3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current
- D. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2 to 10 VDC, feedback signal.
- E. Waterflow Switches: Pressure flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless steel or bronze paddle. For chilled water applications, provide vaporproof type. NEMA 250, Type 1 enclosure.
- F. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors, using solid-state sensors with three year minimum life, maximum 15 minute sensor replacement, suitable over a temperature range of 23 to 130 deg. F., calibrated for 50 and 100 ppm, with maximum 120 second response time to 100 ppm carbon monoxide.
- G. Carbon Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23 to 130 deg. F., calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.
- H. Oxygen Sensor and Transmitter: Single detectors, using solid-state zircon cell sensing, suitable over a temperature range of minus 32 to plus 1100 deg. F., calibrated for 0 to 5 percent, with continuous or averaged reading, 4 to 20 mA output, and wall mounted.
- I. Refrigerant Detectors: Dual-level detectors, using solid-state sensors, with alarm preset for 300 ppm, alarm indicator light, alarm silence light and button, alarm test light and button, and trouble light. Provide auxiliary relay preset for 150 ppm.

- J. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180 degree field of view with vertical sensing adjustment, for flush mounting.
- K. Voltage Transmitter (100 to 600 VAC): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- L. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4 to 20 mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- M. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

2.6 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or 2-position action.
 - 1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - 2. Non-Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 - 3. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
 - 4. Non-Spring-Return Motors for Dampers Larger Than 25 sq. ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 - 5. Spring-Return Motors for Dampers Larger Than 25 sq. ft.: Size for running and breakaway torque of 150 in. x lbf.
- B. Electronic Damper or Large Valve Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 1. Valves: Size for torque required for valve close-off at maximum pump differential pressure
 - 2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. of damper
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper
 - e. Dampers with 2 to 3 Inches w.g. of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Multiply the minimum full-stroke cycles above by 1.5
 - f. Dampers with 3 to 4 Inches w.g. of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Multiply the minimum full-stroke cycles above by 2.0
 - 3. Coupling: V-bolt and V-shaped, toothed cradle
 - 4. Overload Protection: Electronic overload or digital rotation-sensing circuitry
 - 5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators
 - 6. Power Requirements (2 Position Spring Return): 24 or 120 VAC
 - 7. Power Requirements (Modulating): Maximum 10 VA at 24 VAC or 8W at 24 VDC
 - 8. Proportional Signal: 2 to 10 VDC or 4 to 20 mA, and 2 to 10 VDC position feedback signal
 - 9. Temperature Rating: Minus 22 to plus 122 deg. F.
 - 10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg. F.
 - 11. Run Time: 12 seconds open, 5 seconds closed, or as required by application.

2.7 FLOW MEASUREMENT

- A. Air Measuring and Static Pressure Stations: Provide air measuring stations where required for measurement of airflow and for measurement of static pressure. Rectangular units shall be factory-mounted in flanged frames. Round units shall be flanged or slip fit as required. Oval units shall be standard slip fit. Flow stations shall be installed under Section 238800 - AIR DISTRIBUTION.
- B. Sensing units for total and static pressure shall be of copper mounted in galvanized steel frame with copper collector tubes. All interconnecting tubing shall be internal to the unit and shall have one external connection for total pressure and for static pressure. The total and static sensing ports shall be positioned on an equal area basis, with a maximum of 16 sq. in. per pressure port on station smaller than 4 sq. ft. Stations 4 sq. ft. and larger shall have a maximum of 36 sq. in. per pressure port. Units shall have an airflow-straightening device and shall have accuracy such that signals are within ± 2 percent of actual conditions for a range of 700 to 4000 fpm. The measuring station air side pressure drop shall not exceed 0.015 inch w.c. at 1000 fpm and 0.85 inch w.c. at 2000 fpm airflow. The stations shall be designed for fan discharge or normal duct installation as applicable.
- C. Airflow measurement stations shall be by Air Monitor Corporation, Wetmaster Co., Ltd. or approved equal.
- D. Waterflow Measuring Station: Stations shall be Onicon model FB-1210 insertion turbine flow meters suitable for measuring electrically conductive water-based liquids. Meter shall include non-isolated 4-20 mA and 0-10 V analog output signals that are linear with the flow rate as well as a binary (digital) dry contact output for flow direction.
 - 1. Accuracy:
 - a. ± 0.5 percent of reading at calibrated velocity
 - b. ± 1 percent of reading from 3 to 30 ft/s (10:1 range)
 - c. ± 2 percent of reading from 0.4 to 20 ft/s (50:1 range)
 - 2. Sensing Method: Electronic impedance sensing (non-magnetic and non-photoelectric).
 - 3. Pipe Size Range: 2-1/2 inch through 72 inches nominal diameter.
 - 4. Supply Voltage: 24 ± 4 V AC/DC at 90 mA
 - 5. Liquid Temperature Range: 180 deg. F. continuous, 200 deg. F. peak.
 - 6. Ambient Temperature Range: -5 deg. F. to 160 deg. F.
 - 7. Operating Pressure: 400 psi maximum.
 - 8. Pressure Drop: Less than 1 psi at 20 ft/s in 2-1/2 inch pipe, decreasing in larger pipes and lower velocities.
 - 9. Output Signals:
 - a. Directional Contact Output
 - b. Isolated solid state dry contact
 - c. Contact rating: 100 mA, 50 V
 - d. Switch closed when flow is in direction of arrow
 - e. Latches at 0.18 ft/s
 - f. Switches within 20 seconds of direction change
 - g. Analog Output (non-isolated)
 - h. Voltage output: 0-10 V (0-5 available)
 - i. Current output: 4-20 mA
 - j. Frequency Output
 - k. 0 - 15 V peak pulse, typically less than 300 Hertz
 - 10. Materials:
 - a. Wetted Metal Components: Electroless nickel plated brass.
 - b. Electronics Enclosure: Weathertight aluminum enclosure.
 - 11. Electrical Connections:
 - a. 5-wire for minimum for directional switch and either 4-20 mA or 0-10 V output.

- b. Second analog output and/or frequency output requires additional wires.
- c. Standard: 10 ft. of cable with 1/2 inch NPT conduit connection plenum rated cable.

2.8 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Hydronic System Globe Valves NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
- C. Hydronic System Globe Valves NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
- D. Hydronic system globe valves shall have the following characteristics:
 - 1. Rating: Class 125 for service at 125 psig and 250 deg. F. operating conditions
 - 2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs. Use where tight shutoff is required.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 - 3. Sizing: 3 psig maximum pressure drop at design flow rate or the following:
 - a. Two-Position: Line size.
 - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 - 4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 - 5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
- E. Butterfly Valves: 200 psig, 150 psig maximum pressure differential with bubbletight shutoff without need for a downstream flange, ASTM A 126 cast iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
 - 1. Body Style: Lug or Grooved.
 - 2. Disc Type: Aluminum bronze.
 - 3. Sizing: 1 psig maximum pressure drop at design flow rate.
- F. Terminal Unit Control Valves: Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.
 - 1. Rating: Class 125 for service at 125 psig and 250 deg. F. operating conditions.
 - 2. Sizing: 3 psig maximum pressure drop at design flow rate, to close against pump shutoff head.
 - 3. Flow Characteristics: Two way valves shall have equal percentage characteristics; 3 way valves shall have linear characteristics.

2.9 DAMPERS

- A. Dampers: AMCA rated, parallel or opposed blade design; 0.1084 inch minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635 inch galvanized steel with maximum blade width of 8 inch.

1. Blades shall be secured to 1/2 inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg. F.
 3. For standard applications, include optional closed-cell neoprene edging.
 4. For low-leakage applications (such as on outside air and face and bypass application), use parallel or opposed blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inch w.g. when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.
 5. For less critical duty, use opposed-blade design with stainless steel side seals, exposed linkage, rate for leakage at less than 30 cfm per sq. ft. of damper area at differential pressure of 3 inch w.g.
 6. For non-critical duty (such as for exhaust, relief and return air applications) use parallel-blade dampers with stainless steel side seals, exposed linkage, rate for leakage at less than 30 cfm per sq. ft. of damper area at differential pressure of 3 inch w.g.
- B. Manufacturers: Equipment shall be by Ruskin Company. Equipment by CESCO Products, Greenheck, Nailor Industries Inc., Penn Ventilation Company, Inc., or American Warming and Ventilating, meeting the above specifications will be considered for approval.

2.10 LABORATORY AIR VALVES/FUME HOOD CONTROLS

- A. Provide a laboratory control system to control the exhaust airflow out of laboratory classrooms and makeup air to the laboratory classrooms. The exhaust volume of a laboratory fume hood shall be controlled to maintain an average face velocity of 80 ft. per minute into the fume hood. The airflow at the fume hood shall not be varied below the scheduled minimum flow set point. The makeup air volume shall be controlled to maintain the scheduled offset within the laboratory. Provide all air valves with electronics to provide flow feedback to the Building Automation System.
- B. The system shall include laboratory air valves, controllers, and all startup and checkout to result in a completely operational system.
- C. Laboratory airflow controls systems shall be fully compatible with the Building Automation System. Laboratory control systems shall interface with the Building Automation System at the laboratory room level. Laboratory control systems shall remain actively functional at the laboratory room level regardless of the Building Automation System status.
- D. Air Valves:
1. The air valves shall be of the Venturi valve control type.
 2. The valves shall be pressure independent over their scheduled range of static pressure drop. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.
 3. Airflow accuracy shall be ± 5 percent of signal over an airflow turndown range of no less than 10:1. No minimum entrance or exit duct diameters shall be required to ensure speed of response, accuracy, or pressure independence.
 4. Construction:
 - a. General exhaust valve, point exhaust valve and supply air valve assemblies shall be constructed of 16 gauge aluminum. The assembly's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester, or polyphenylene sulfide (PPS) composite.

- b. Hood exhaust valve assemblies shall have a baked-on corrosion resistant phenolic coating. The assembly's shaft shall be 316 stainless steel with a Teflon coating. The pivot arm, shaft support brackets, and internal mounting link shall be made of 316 stainless steel. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester, or polyphenylene sulfide (PPS) composite.
 - 5. Actuation: For variable-air-volume air valves, provide an electric actuator factory mounted to the valve. The air valves shall modulate based on a 0 to 10 volt electronic signal. The valve shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow. Loss of power shall cause exhaust valves to fail open to the maximum scheduled design flow and supply valves to fail to the minimum scheduled design flow. Constant volume valves do not require actuators.
 - 6. Certification:
 - a. Each air valve shall be factory calibrated to its scheduled airflows. Each electronic valve shall be further calibrated and its accuracy verified to ± 5 percent of signal at eight different airflows across the full operating range.
 - b. All air valves shall be individually marked with valve specific, factory calibration data. As a minimum, the data should include valve tag number, serial number, model number, eight point valve characterization information, and quality control inspection numbers.
 - E. Constant Volume Air Valve Controllers: The airflow control device shall maintain a constant airflow set point. It shall be factory characterized and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
 - F. Monitoring:
 - 1. The laboratory control system shall generate electronic signals linearly proportional to all airflow sources, sash sensors, and flow alarms. The control system shall interface into the Building Automation System. The following signals (points) shall be available:
 - a. Fume hood exhaust flow and hood face velocity.
 - b. Fume hood exhaust low flow alarm.
 - c. Air valve low differential static pressure.
 - G. Manufacturer: Subject to compliance with requirements, provide products by Phoenix Controls Corporation. Valves and laboratory control systems by Price will be considered for approval.
- 2.11 SMOKE DETECTORS
- A. Furnished under Division 26. The Contractor shall provide connection from the smoke detector auxiliary contacts to the fan starter control circuits and to the DDC panel for program usage. Coordinate with Division 26 Contractor for preferred location of fire alarm command module.
- 2.12 CONTROL CABLE
- A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct, pipe, and equipment-mounted devices and wiring and pneumatic piping are installed before proceeding with installation.

3.2 INSTALLATION

- A. Install equipment level and plumb.

- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Connect and configure equipment and software to achieve sequence of operation specified.
- D. Verify location of thermostats, humidistats, and other exposed control sensors with Architectural plans and sections.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- E. Install guards on thermostats in the following locations:
 - 1. Entrances
 - 2. Public areas
 - 3. Where indicated
- F. Install automatic dampers according to Section 238800 - AIR DISTRIBUTION.
- G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Install labels and nameplates to identify control components according to Section 230500 - BASIC MECHANICAL MATERIALS AND METHODS.
- I. Install labels and nameplates to identify control components according to Section 231900 - MECHANICAL IDENTIFICATION.
- J. Install hydronic, refrigerant, steam and condensate instrument wells, valves, and other accessories according to Section 230600 - PIPING.
- K. Install duct volume-control dampers according to Section 238800 - AIR DISTRIBUTION.
- L. Install electronic and fiber-optic cables according to Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).
- M. Install control panels in clear, accessible area where hinged door can open completely. Provide a drop-down shelf at control panel for support of laptop computer or calibration equipment. Provide rubber/neoprene bushings in panel knockouts to prevent raw edges from damaging wire.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Section 261300 - RACEWAYS AND BOXES.
- B. Install building wire and cable according to Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).
- C. Install signal and communication cable according to Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number code or color code conductors for future identification and service of control system, except local individual room control cables.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to machine to allow service and maintenance.
- B. Ground Equipment: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
 - 3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 6. Test each system for compliance with sequence of operation.
 - 7. Test software and hardware interlocks.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
 - 1. Start, test, and adjust control systems.
 - 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
 - 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
 - 4. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
- D. Verify DDC as follows:
 - 1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
 - 2. Verify operation of operator workstation.
 - 3. Verify local control units including self-diagnostics.
- E. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 - 4. Check temperature instruments and material and length of sensing elements.
 - 5. Check control valves. Verify that they are in correct direction.

6. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

3.6 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours dedicated instructor time on-site.
 - 3. Review data in maintenance manuals. Refer to Division 01 Section "Contract Closeout."
 - 4. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
 - 5. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.8 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three (3) Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.9 SEQUENCE OF OPERATION

- A. General:
 - 1. The Building Automation System (BAS) shall integrate with the campus automation system and shall include the extension or connection to the campus network for communications to central campus workstation.
 - 2. It is the BAS Contractor's responsibility to coordinate factory mounted and supplied controls by the equipment manufacturer with the following sequence of operation. Equipment monitoring identified in sequence that shall be integrated into the BAS for remote monitoring at central workstation or laptop see Section 235000. The BAS contractor shall provide overall system startup services including equipment supplied controls.
 - 3. Provide one (1) laptop computer with software for field connections to controllers and devices, and at the building automation central control panel. Major equipment, control valve/damper position, temperature/humidity readings or set points, and all status/alarms shall be displayed on the BAS graphics for each system.
 - 4. This Contractor shall furnish all electrical power for Instrumentation and Control System - controllers, devices, combination fire-smoke dampers, and actuators associated with the HVAC controls and mechanical systems.
 - 5. Connections to campus chilled water system shall provide cooling for the new building. Booster/building variable speed pumps (one operating/on standby) located on Level 0 will circulate chilled water to the new central and Cadaver Lab AHU equipment. Booster pumps are provided for AHU-5 (electrical room ventilation) and the process cooling system on Level 04.
 - 6. Air handling systems and zoned air terminal units with heating coils shall deliver prescribed ventilation air and zone temperature control. AHU-1 and AHU-2 service all spaces except for the Cadaver lab suite, which is served from AHU-3 or AHU-4. Provide isolation dampers at the inlet and outlets of each air handling unit for individual unit operations.
 - 7. Heating for buildings shall originate from two (2) condensing boilers located in the Level 01 equipment room with heating water loop pumps located on Level 0. Each boiler is sized for two-thirds the peak heating load. The heating system shall include a cross-connection between the EAB boilers and the new building boilers with 2-way/2-position, normally closed control valves to isolate the two systems and manually operated from the BAS workstation.

8. The following is a list of major HVAC systems:
 - a. Building/Booster Chilled Water Pumps CP-1 and CP-2
 - b. Heating Water Boilers and associated Heating Pumps B-1, B-2, HP-1, and HP-2
 - c. Central Air Handling System - AHU-1, FZP-1, AHU-2, FZP-2, and EF-2
 - d. Cadaver Lab Air Handling Units - AHU-3, CU-1, FZP-3, AHU-4, CU-2, and FZP-4
 - e. Main Electrical Room Ventilation Air Handling Unit - AHU-5 and CP-3
 - f. Heat Recovery run-around loop System - HRP-1 and HRP-2 with coils in AHU-1, AHU-2, and HEF-1
 - g. Air Terminal Units - VAV units
 - h. Laboratory Space Controls and Exhaust System - HEF-1 and associated Hood Exhaust Valves, Supply Air Valves, General Exhaust Air Valve, and Laboratory Space Controls
 - i. Process Cooling System - PHX-1, CP-4A, CP-4B, PCP-1A, and PCP-1B
 - j. Kitchen Hood Exhaust - KEF-1
 - k. Central Toilet Exhaust - EF-1
 - l. Ventilation Fans - VF-1 (L0 Mech Rm), VF-2 (L1 Elev. Control Rm), and VF-3 (L1 AV Control Rm)
 - m. Data Closet Cooling Systems - FCU-1/ACCU-2, FCU-2/ACCU-2, FCU-3/ACCU-3, FCU-4/ACCU-4, and FCU-5(A/B/C)/ACCU-5
 - n. Space Heating Units - Unit Heaters (UH) and Cabinet Unit Heater (CUH)
 - o. Overhang Soffit Heating - Fin Tube Radiation (FTR)
- B. Building/Booster Chilled Water Pumps CP-1 and CP-2:
 1. Run Conditions:
 - a. The chilled water pumps shall be enabled whenever:
 - 1) A definable number of chilled water coils need cooling.
 2. To prevent short cycling, the chilled water pump system shall run for and be off for minimum adjustable times (both user definable).
 3. Chilled Water Pump Lead/Lag Operation: The two (2) variable speed chilled water pumps shall operate in a lead/lag fashion.
 - a. The lead pump shall run first.
 - b. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
 - c. On decreasing chilled water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain chilled water differential pressure set point.
 4. The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - a. manually through a software switch
 - b. if pump runtime (adj.) is exceeded
 - c. daily
 - d. weekly
 - e. monthly
 5. Alarms shall be provided as follows:
 - a. Chilled Water Pump 1:
 - 1) Failure: Commanded on, but the status is off.
 - 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) AFC Fault.
 - b. Chilled Water Pump 2:
 - 1) Failure: Commanded on, but the status is off.

- 2) Running in Hand: Commanded off, but the status is on.
- 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
- 4) AFC Fault.

6. Chilled Water Differential Pressure Control:

- a. The controller shall measure chilled water differential pressure and modulate the chilled water pump AFCs in sequence to maintain its chilled water differential pressure set point. The following set points are recommended values. All set points shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.
- b. The controller shall modulate chilled water pump speeds to maintain a chilled water differential pressure of 10 psi (adj.). The AFCs minimum speed shall not drop below 20 percent (adj.).
- c. On dropping chilled water differential pressure, the AFCs shall stage on and run to maintain set point as follows:
 - 1) The controller shall modulate the lead AFC to maintain set point.
 - 2) If the lead AFC speed is greater than a set point of 90 percent (adj.), the lag AFC shall stage on.
 - 3) The lag AFC shall ramp up to match the lead AFC speed and then run in unison with the lead AFC to maintain set point.
- d. On rising chilled water differential pressure, the AFCs shall stage off as follows:
 - 1) If the AFCs speed then drops back to 60 percent (adj.) below set point, the lag AFC shall stage off.
 - 2) The lead AFC shall continue to run to maintain set point.
- e. Alarms shall be provided as follows:
 - 1) High Chilled Water Differential Pressure: If the chilled water differential pressure is 25 percent (adj.) greater than set point.

- C. Low Chilled Water Differential Pressure: If the chilled water differential pressure is 25 percent (adj.) less than set point.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Chilled Water Differential Pressure	X							X		X
Chilled Water Pump AFC Speed *		X						X		X
Chilled Water Pump Status *			X					X		X
Chilled Water Pump AFC Fault *			X						X	X
Chilled Water Pump Start/Stop *				X				X		X
Chilled Water Differential Pressure Set point					X					X
Chilled Water Pump Failure *									X	
Chilled Water Pump Running in Hand *									X	
Chilled Water Pump Runtime Exceeded *									X	
High Chilled Water Differential Pressure									X	
Low Chilled Water Differential Pressure									X	

* Point applies to each pump

- D. Heating Water Boilers and associated Heating Pumps B-1, B-2, HP-1, and HP-2:
1. Boiler System (B-1 and B-2) Run Conditions:
 - a. The boiler system shall be enabled to run whenever:
 - 1) A definable number of heating water coils need heating.
 - b. To prevent short cycling, the boiler system shall run for and be off for minimum adjustable times (both user definable), unless shutdown on safeties or outside air conditions.
 - c. The boiler shall run subject to its own internal safeties and controls.
 2. Boiler Safeties:
 - a. The following safeties shall be monitored and alarmed:
 - 1) Boiler alarm.
 - 2) Low water flow.
 3. Boiler Lead/Lag Operation:
 - a. The boilers shall operate in a lead/lag fashion.
 - 1) Lead boilers shall run first.
 - 2) On failure of lead boiler, the lag boiler shall run and the failed lead boiler shall turn off.
 - 3) As heating water supply temperature drops below a set point of 140 deg. F. (adj.), the next lag boiler shall stage on and run in unison with the lead boiler(s) to maintain heating water temperature set point.
 - 4) As heating water temperature rises back to 10 deg. F. (adj.) above set point, the lag boiler shall stage off.
 - b. The designated lead boiler shall rotate upon one of the following conditions: (user selectable):
 - 1) manually through a software switch
 - 2) if boiler runtime (adj.) is exceeded
 - 3) daily
 - 4) weekly
 - 5) monthly
 - c. Alarms shall be provided as follows:
 - 1) Boiler:
 - a) Failure: Commanded on, but the status is off.
 - b) Running in Hand: Commanded off, but the status is on.
 - c) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 2) Lead Boiler Failure: The lead boiler is in failure and the lag (standby) boiler is on.
 4. Boiler Heating Water Temperature Control and Monitoring:
 - a. Provide heating water supply temperature reset based on heating demand from initial setting of 140 deg. F. down to 80 deg. F.
 - b. The following temperatures shall be monitored:
 - 1) Boiler heating water supply.
 - 2) Boiler heating water return.
 - c. Alarms shall be provided as follows:
 - 1) High Heating Water Supply Temp: If greater than 160 deg. F. (adj.).
 - 2) Low Heating Water Supply Temp: If less than 60 deg. F. (adj.).

Point Name*	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Boiler Heating Water Return Temp	X							X		X
Boiler Heating Water Supply Temp	X							X		X
Boiler Heating Water Supply Temp Set point Reset		X						X		X
Boiler Alarm Status *			X					X	X	X
Boiler Low Water Level *			X					X	X	X
Boiler Status *			X					X		X
Boiler Enable *				X						X
Boiler Failure *									X	
Boiler Running in Hand *									X	
Boiler Runtime Exceeded *									X	
Lead Boiler Failure *									X	X
Boiler High Heating Water Supply Temp *									X	
Boiler Low Heating Water Supply Temp *									X	

* Point applies to each boiler.

5. Heating Water Loop Pumps (HP-1 and HP-2):

a. Heating Water Pump Run Conditions:

- 1) The heating water pumps shall be enabled whenever:
 - a) A definable number of heating water coils need heating.
- 2) The pumps shall run for freeze protection anytime outside air temperature is less than 38 deg. F. (adj.).
- 3) To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable).

b. Heating Water Pump Lead/Lag Operation:

- 1) The two (2) variable speed heating water pumps shall operate in a lead/lag fashion.
 - a) The lead pump shall run first.
 - b) On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
 - c) On decreasing heating water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain heating water differential pressure set point.
- 2) The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - a) manually through a software switch
 - b) if pump runtime (adj.) is exceeded
 - c) daily
 - d) weekly
 - e) monthly
- 3) Alarms shall be provided as follows:
 - a) Failure: Commanded on, but the status is off.
 - b) Running in Hand: Commanded off, but the status is on.
 - c) Runtime Exceeded: Status runtime exceeds a user definable limit.

- d) AFC Fault.
 - c. Heating Water Differential Pressure Control:
 - 1) The controller shall measure heating water differential pressure and modulate the heating water pump AFC s in sequence to maintain its heating water differential pressure set point.
 - 2) The following set points are recommended values. All set points shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.
 - 3) The controller shall modulate heating water pump speeds to maintain a heating water differential pressure of 12 psi (adj.). The AFC s minimum speed shall not drop below 15 percent (adj.).
 - 4) On dropping heating water differential pressure, the AFCs shall stage on and run to maintain set point as follows:
 - a) The controller shall modulate the lead AFC to maintain set point.
 - b) If the lead AFC speed is greater than a set point of 90 percent (adj.), the lag AFC shall stage on.
 - c) The lag AFC shall ramp up to match the lead AFC speed and then run in unison with the lead AFC to maintain set point.
 - 5) On rising heating water differential pressure, the AFC s shall stage off as follows:
 - a) If the AFC s speeds drops back to 60 percent (adj.) below set point, the lag AFC shall stage off.
 - b) The lead AFC shall continue to run to maintain set point.
 - 6) Alarms shall be provided as follows:
 - a) High Heating Water Differential Pressure: If 25 percent (adj.) greater than set point.
 - b) Low Heating Water Differential Pressure: If 25 percent (adj.) less than set point.
 - d. Heating Water Loop Temperature Monitoring:
 - 1) The following temperatures shall be monitored:
 - a) Heating water loop supply.
 - b) Heating water loop return.
 - 2) Alarms shall be provided as follows:
 - a) High Heating Water Loop Supply Temp: If the heating water supply temperature is greater than 160 deg. F. (adj.).
 - b) Low Heating Water Loop Supply Temp: If the heating water supply temperature is less than 60 deg. F. (adj.).
6. East Academic Building (EAB) cross-connection valves:
- a. Provide normally closed, two position, control valves in the supply and return cross-connection lines. Valves shall only open on a manual command from the workstation.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Heating Water Differential Pressure	X							X		X
Heating Water Loop Return Temp	X							X		X
Heating Water Loop Supply Temp	X							X		X

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Heating Water Pump AFC Speed *		X						X		X
Heating Water Pump Status *			X					X		X
Heating Water Pump AFC Fault *			X						X	X
Heating Water Pump Start/Stop *				X				X		X
Heating Water Differential Pressure Set point					X					X
High Heating Water Differential Pressure									X	
Low Heating Water Differential Pressure									X	
Heating Water Pump Failure *									X	
Heating Water Pump Running in Hand *									X	
Heating Water Pump Runtime Exceeded *									X	
High Heating Water Loop Supply Temp									X	
Low Heating Water Loop Supply Temp									X	
EAB cross-connection Valve				X						X

* Point applies to each pump.

- E. Central Air Handling System - AHU-1, FZP-1, AHU-2, FZP-2, and EF-2. This system serves all spaces except for the Cadaver lab suite. Both AHUs are required to meet building loads. Provide isolation dampers at the inlet and outlets of each air handling unit for individual unit operations during low loads or unit maintenance.

1. Run Conditions - Requested:
 - a. The unit shall run whenever:
 - 1) Any zone is occupied.
 - 2) OR a definable number of unoccupied zones need heating or cooling.
2. Freeze Protection: The unit shall shutdown and generate an alarm upon receiving a freezestat status.
3. High/Low Static Shutdown: The unit shall shutdown and generate an alarm upon receiving a high or low static shutdown signal.
4. Return Air Smoke Detection: The unit shall shutdown and generate an alarm upon receiving a return air smoke detector status.
5. Supply and Return Isolation Dampers: The dampers shall open anytime the supply fan starts. Coordinate damper speed with fan starting speed to prevent recirculation if one AHU is already operating.
6. Supply Fan: The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Alarms shall be provided as follows:
 - a. Supply Fan Failure: Commanded on, but the status is off.
 - b. Supply Fan in Hand: Commanded off, but the status is on.
 - c. Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
7. Supply Air Duct Static Pressure Control: The controller shall measure duct static pressure at multiple locations and modulate the supply fan AFC speed to maintain a duct static pressure set point. The speed shall not drop below 15 percent (adj.). The static pressure set point shall be reset based on zone cooling requirements or discharge duct static pressure set point optimization described below:

- a. The building automation system (BAS) shall continually monitor the damper position of all VAV terminal units. The discharge duct static pressure shall be sensed directly at the discharge of each air handler. Mount the sensor in a non-turbulent location.
 - b. When any VAV damper is more than 75 percent (adj.) open, the supply fan discharge duct static pressure set point shall be reset upward by 0.1 in w.c. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75 percent open or the static pressure set point has reset upward to the system maximum duct static pressure set point or the AHU adjustable frequency controller is at the maximum speed setting.
 - c. When all VAV dampers are less than 65 percent (adj.) open, the supply fan discharge duct static pressure set point shall be reset downward by 0.1 in w.c. (adj.), at a frequency of 15 minutes (adj.), until at least one damper is more than 65 percent open or the static pressure set point has reset downward to the system minimum duct static pressure set point or the AHU adjustable frequency controller is at the minimum speed setting.
 - d. The control bands, set point increment values, set point decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.
 - 1) The initial discharge static pressure set point shall be 2.0 in H2O (adj.).
 - 2) As cooling demand increases, the set point shall incrementally reset up to a maximum of 3.5 in H2O (adj.).
 - 3) As cooling demand decreases, the set point shall incrementally reset down to a minimum of 1.5 in H2O (adj.).
 - e. The BAS shall have the capability to allow the operator to exclude "problem" zones that should not be considered when determining the optimized set point.
 - f. The BAS shall also read the status of the supply air static pressure sensor and display the active duct static pressure reading on the status screen. Locate supply air duct static pressure sensor as shown on drawings. Mount the sensors in a non-turbulent location.
 - g. The BAS shall have the ability to identify, and display to the user, the VAV terminal unit that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure set point optimization control.
 - h. Alarms shall be provided as follows:
 - 1) High Supply Air Static Pressure: If the supply air static pressure is 25 percent (adj.) greater than set point.
 - 2) Low Supply Air Static Pressure: If the supply air static pressure is 25 percent (adj.) less than set point.
 - 3) Supply Fan AFC Fault.
 - i. During the commissioning process, the Controls Contractor shall demonstrate the performance of fan pressure optimization.
8. Exhaust Fan:
- a. The exhaust fan shall run anytime the air handling units are operating. The controller shall measure duct static pressure and modulate the exhaust fan AFC speed to maintain a duct static pressure set point, -0.25 in. H2O (adj.). The speed shall not drop below 15 percent (adj.).
 - b. The Exhaust fan shall run to control building pressurization. Alarms shall be provided as follows:
 - 1) Exhaust Fan Failure: Commanded on, but the status is off.
 - 2) Exhaust Fan in Hand: Commanded off, but the status is on.

- 3) Exhaust Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
 - 4) Exhaust Fan AFC Fault.
9. Building Pressurization Control: The controller shall measure, calculate, and gather airflow information from building system, including Lab airflow control system. BAS shall also include exhaust airflow quantities from operating constant flow fans in building pressurization calculations.
 - a. The BAS shall continually monitor total supply and exhaust airflow for each floor and modulate the associated return air damper to maintain positive pressure.
 - 1) Total floor return airflow (RA) shall equal the total floor supply airflow (SA) minus the total floor exhaust airflow (EA) minus the floor pressurization (PRZ) 500-cfm (adj.):
 - a) 01SA - 01EA - 01PRZ (adj.) = 01RA
 - b) 02SA - 02EA - 02PRZ (adj.) = 02RA
 - c) 03SA - 03EA - 03PRZ (adj.) = 03RA
 - d) 04SA - 04EA - 04PRZ (adj.) = 04RA
 - b. Ventilation Airflow: Reset the minimum outside airflow to meet the total building exhaust airflow plus building pressurization, 2,000-cfm (adj.)
10. Supply Air Temperature Set point - Optimized:
 - a. The controller shall monitor the supply air temperature, main return air relative humidity, and shall maintain a supply air temperature set point reset based on outside air temperature.
 - b. The supply air temperature set point shall be reset for cooling based on outside air temperature as follows:
 - 1) The initial supply air temperature set point shall be 55 deg. F (adj.).
 - 2) As the outside air temperature increases above 55 deg. F. (adj.), the set point shall incrementally reset down to a minimum of 52 deg. F (adj.).
 - 3) As the outside air temperature decreases below 45 deg. F. (adj.), the set point shall incrementally reset up to a maximum of 60 deg. F (adj.).
 - 4) Override supply air reset optimization if main return air relative humidity increases above 60 percent RH at 75 deg. F. (adj.) and incrementally reset supply air down to a minimum of 52 deg. F. (adj.).
11. Cooling Coil Valve:
 - a. The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling set point. The cooling shall be enabled whenever:
 - 1) Outside air temperature is greater than 60 deg. F (adj.).
 - 2) AND the economizer is disabled or fully open.
 - 3) AND the supply fan status is on.
 - 4) AND the heating is not active.
 - b. The cooling coil valve shall open to 50 percent (adj.) whenever the freezestat is on.
 - c. Alarms shall be provided as follows:
 - 1) High Supply Air Temp: If the supply air temperature is 5 deg. F. (adj.) greater than set point.
12. Heating Coil Valve: The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its heating set point.
 - a. The heating shall be enabled whenever:
 - 1) Outside air temperature is less than 65 deg. F. (adj.).
 - 2) AND the supply fan status is on.
 - 3) AND the cooling is not active.

- b. The heating coil valve shall open whenever:
 - 1) Supply air temperature drops from 40 deg. F. to 35 deg. F. (adj.).
 - 2) OR the freezestat is on.
 - c. Alarms shall be provided as follows:
 - 1) Low Supply Air Temp: If the supply air temperature is 5 deg. F. (adj.) less than set point.
13. Heating Coil Freeze Prevention Pump (FZP):
- a. The recirculation pump shall run whenever the outside air temperature is below 38 deg. F (adj.) or if the freezestat is on.
 - b. Alarms shall be provided as follows:
 - 1) Heating Coil Pump Failure: Commanded on, but the status is off.
 - 2) Heating Coil Pump in Hand: Commanded off, but the status is on.
 - 3) Heating Coil Pump Runtime Exceeded: Status runtime exceeds a user definable limit.
14. Economizer:
- a. The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a set point 2 deg. F. (adj.) less than the supply air temperature set point. The outside air dampers shall maintain a minimum adjustable position of 20 percent (adj.) open whenever occupied.
 - 1) The economizer shall be enabled whenever:
 - a) Outside air temperature is less than 65 deg. F. (adj.)
 - b) AND the outside air enthalpy is less than 22 Btu/lb (adj.)
 - c) AND the outside air temperature is less than the return air temperature.
 - d) AND the outside air enthalpy is less than the return air enthalpy.
 - e) AND the supply fan status is on.
 - 2) The economizer shall close whenever:
 - a) Mixed air temperature drops from 40 deg. F. to 35 deg. F. (adj.)
 - b) OR the freezestat is on.
 - c) OR on loss of supply fan status.
 - b. The outside air, supply air, and return air dampers shall close when the unit is off. If Optimal Start Up is available the supply and return air damper shall open as described in the occupied mode and the outside air damper shall remain fully closed.
15. Demand Ventilation Optimization:
- a. The AHU minimum outdoor-air damper shall be controlled to deliver required outdoor airflow at all occupied load conditions and to makeup exhaust airflow. The outdoor airflow set point for space other than laboratory areas shall be determined according to ASHRAE Standard 62.1-2007, Equation 6-8 and Appendix A. Provide an alarm at the workstation if the minimum airflow should deviate from set point by more than 10 percent. The outdoor airflow set point shall primarily be determined by the total exhaust airflow plus building pressurization, see Building Pressurization Control section. The occupied minimum outside airflow shall not drop below 20,000 cfm (adj.) and the unoccupied minimum airflow shall match the unoccupied exhaust airflow plus 2,000 cfm (adj.) for building pressurization, but not less than 15,000 cfm. The actual minimum outdoor airflow shall be sensed at the outdoor air intake via an airflow measuring station.

- b. The BAS shall include three methods for determining space occupancy, Time Of Day (TOD) scheduling, occupancy (OCC) sensors, and Carbon dioxide (CO₂) sensors.
 - 1) TOD spaces shall include public spaces not included in other methods. The time-of-day schedule shall indicate whether a zone is normally occupied or unoccupied. When the schedule indicates that the zone is normally unoccupied, the required outdoor airflow for the zone shall be zero. When the schedule indicates that the zone is normally occupied, the required outdoor airflow for the zone shall equal the design outdoor airflow (based on design occupancy).
 - 2) Private offices shall be equipped with an occupancy sensor, provided by Division 26 Contractor. The required outdoor airflow for the zone shall be continuously determined based on whether people are present or not. When the occupancy sensor indicates that people are present in the zone, the required outdoor airflow shall equal the design outdoor airflow. When the occupancy sensor indicates that no people are present in the zone, the required outdoor airflow shall equal the "unoccupied" outdoor airflow.
 - 3) Large occupancy spaces with more than 500 square foot floor area and occupancy greater than 25 people per 1000 square foot of floor area, as listed below, shall be equipped with a CO₂ sensor. As the CO₂ concentration in the space rises, increase the AHU minimum outside airflow by the as listed below
 - a) VAV-110; 131 Health Assessment Lab, 260 cfm (100 cfm to 360 cfm)
 - b) VAV-113; 135 Dry Skills Lab, 260 cfm (110 cfm to 370 cfm)
 - c) VAV-115; 140 Conference Room, 130 cfm (50 cfm to 180 cfm)
 - d) VAV-123 and VAV-124; 160 Lecture Hall, 930 cfm (130 cfm to 1060 cfm)
 - e) VAV-209; 231 Computer Lab/General Clrm, 260 cfm (80 cfm to 340 cfm)
 - f) VAV-210; 233 General Classroom, 260 cfm (80 cfm to 340 cfm)
 - g) VAV-321; 353 Quantitative/Interview Lab, 260 cfm (100 cfm to 360 cfm)
- c. The required outdoor-air fraction shall be continuously calculated for each VAV terminal zone. Outdoor-air fraction is defined, as the current required outdoor airflow for the zone divided by the current primary airflow to the zone.
- d. The BAS shall regularly determine the highest zone outdoor-air fraction, sum the outdoor airflow requirements for all VAV zones, and sum the current primary airflows for all VAV zones to determine the total system primary airflow. This information shall be used in Equation 6-8 and Appendix A of ASHRAE Standard 62.1-2007 to calculate the minimum required outdoor airflow for the system. This minimum outdoor airflow set point shall be recalculated every 15 minutes (adj.).
- e. The VAV Air System shall not request a higher percentage of outdoor air than the AHU is able to provide. This Ventilation Ratio Limit (adj.) of the AHU is dependent on the capacity of the AHU and the current outdoor air temperature and humidity conditions.
- f. Prior to final system acceptance, a Contractor shall provide a trend log of actual system operation to the engineer and Owner. Operating conditions to be logged include: highest zone outdoor-air fraction, total system primary airflow, calculated outdoor airflow set point for the system, and the actual measured outdoor airflow. These conditions must be logged at 15-minute intervals over a typical 24-hour period.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Supply Duct Air Static Pressure	X							X	X	X
Return Plenum Static Pressure	X							X	X	X
AHU Discharge Static Pressure	X							X	X	X
Building Static Pressure	X							X		X
Supply Fan AFC Speed		X						X		X
Return Fan AFC Speed		X						X		X
Freezestat			X					X	X	X
High Discharge Static Shutdown			X					X	X	X
Low Inlet Static Shutdown			X					X	X	X
Return Air Smoke Detector			X					X	X	X
Supply Air Smoke Detector			X					X	X	X
Supply Fan AFC Fault			X						X	X
Supply Fan Status			X					X		X
Return Fan AFC Fault			X						X	
Return Fan Status			X					X		X
Supply Fan Start/Stop				X				X		X
Return Fan Start/Stop				X				X		X
Supply Air Static Pressure Set point					X			X		X
Return Air Static Pressure Set point					X			X		X
Building Static Pressure Set point					X					X
High Discharge Static Pressure									X	
Low Inlet Static Pressure									X	
Supply Fan Failure									X	
Supply Fan in Hand									X	
Supply Fan Runtime Exceeded									X	
High Building Static Pressure									X	
Low Building Static Pressure									X	
Return Fan Failure									X	
Return Fan in Hand									X	
Return Fan Runtime Exceeded									X	
High Return Air Static Pressure									X	
Low Return Air Static Pressure									X	
Critical VAV Terminal unit					X					X
Problem VAV Terminal unit					X					X
Heating Coil Pump Start/Stop				X				X		X
Supply Air Temp Set point					X			X		X
Economizer Mixed Air Temp Set point					X			X		X
Outside Airflow Set point					X			X		X

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Cooling Valve		X						X		X
Heating Valve		X						X		X
Return Air Relative Humidity	X							X		X
Return Air Temperature	X							X		X
Return Air Carbon Dioxide PPM	X							X		X
Mixed Air Temp	X							X		X
Outside Air Temp					X					X
Outside Air Enthalpy					X					X
Emergency Shutdown						X		X	X	X
Heating Coil Pump Failure									X	
Heating Coil Pump in Hand									X	
Heating Coil Pump Runtime Exceeded									X	
Prefilter Change Required									X	X
High Mixed Air Temp									X	
Low Mixed Air Temp									X	
High Return Air Carbon Dioxide Concentration									X	
High Supply Air Temp									X	
Low Supply Air Temp									X	
High Return Air Temp									X	
Low Return Air Temp									X	
Minimum Outside Air out of range by 10 percent									X	

- F. Cadaver Lab Air Handling Units - AHU-3, CU-1, FZP-3, AHU-4, CU-2, and FZP-4. This system serves the Cadaver Lab Suite. The system is designed for full redundancy; one AHU is required for the Cadaver Lab Suite loads and the DX condensing units are backup to the campus chilled water. Provide isolation dampers at the inlet and outlets of each air handling unit for individual unit operations.
1. Run Conditions - The system shall run continuously unless commanded off from the workstation.
 2. Freeze Protection: The unit shall shutdown and generate an alarm upon receiving a freezestat status.
 3. High/Low Static Shutdown: The unit shall shutdown and generate an alarm upon receiving a high or low static shutdown signal.
 4. Supply Air Smoke Detection: The unit shall shutdown and generate an alarm upon receiving a supply air smoke detector status.
 5. Discharge and Inlet Isolation Dampers: The dampers shall open anytime the supply fan starts. Coordinate damper speed with fan starting speed to prevent recirculation if one AHU is already operating.
 6. Supply Fan: The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Alarms shall be provided as follows:
 - a. Supply Fan Failure: Commanded on, but the status is off.
 - b. Supply Fan in Hand: Commanded off, but the status is on.
 - c. Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

7. Supply Air Duct Static Pressure Control: The controller shall measure duct static pressure at multiple locations and modulate the supply fan AFC speed to maintain a duct static pressure set point. The speed shall not drop below 15 percent (adj.). The static pressure set point shall be reset based on zone cooling requirements or discharge duct static pressure set point optimization described below:
 - a. The building automation system (BAS) shall continually monitor the damper position of all VAV terminal units. The discharge duct static pressure shall be sensed directly at the discharge of each air handler. Mount the sensor in a non-turbulent location.
 - b. When any VAV damper is more than 75 percent (adj.) open, the supply fan discharge duct static pressure set point shall be reset upward by 0.1 inch w.c. (adj.), at a frequency of 15 minutes (adj.), until no damper is more than 75 percent open or the static pressure set point has reset upward to the system maximum duct static pressure set point or the AHU adjustable frequency controller is at the maximum speed setting.
 - c. When all VAV dampers are less than 65 percent (adj.) open, the supply fan discharge duct static pressure set point shall be reset downward by 0.1 inch w.c. (adj.), at a frequency of 15 minutes (adj.), until at least one damper is more than 65 percent open or the static pressure set point has reset downward to the system minimum duct static pressure set point or the AHU adjustable frequency controller is at the minimum speed setting.
 - d. The control bands, set point increment values, set point decrement values and adjustment frequencies shall be adjusted to maintain maximum static pressure optimization with stable system control and maximum comfort control.
 - 1) The initial discharge static pressure set point shall be 2.0 inch H₂O (adj.).
 - 2) As cooling demand increases, the set point shall incrementally reset up to a maximum of 3.5 in H₂O (adj.).
 - 3) As cooling demand decreases, the set point shall incrementally reset down to a minimum of 1.5 in H₂O (adj.).
 - e. The BAS shall have the capability to allow the operator to exclude "problem" zones that should not be considered when determining the optimized set point.
 - f. The BAS shall also read the status of the supply air static pressure sensor and display the active duct static pressure reading on the status screen. Locate supply air duct static pressure sensor for monitoring on Level 00 mechanical room before duct riser. Mount the sensors in a non-turbulent location.
 - g. The BAS shall have the ability to identify, and display to the user, the VAV terminal unit that serves the Critical Zone (that is, the zone with the most wide-open VAV damper). This information shall update dynamically as the location of the Critical Zone changes based on building load, and duct static pressure set point optimization control.
 - h. Alarms shall be provided as follows:
 - 1) High Supply Air Static Pressure: If the supply air static pressure is 25 percent (adj.) greater than set point.
 - 2) Low Supply Air Static Pressure: If the supply air static pressure is 25 percent (adj.) less than set point.
 - 3) Supply Fan AFC Fault.
 - i. During the commissioning process, the Controls Contractor shall demonstrate the performance of fan pressure optimization.
8. Supply Air Temperature Set Point:
 - a. The supply air temperature set point shall be 50 deg. F (adj.).

9. Cooling Coil Valve:
 - a. The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling set point. The cooling shall be enabled whenever:
 - 1) Outside air temperature is greater than 50 deg. F (adj.).
 - 2) AND the supply fan status is on.
 - 3) AND the heating is not active.
 - b. The cooling coil valve shall open to 50 percent (adj.) whenever the freezestat is on.
 - c. Alarms shall be provided as follows:
 - 1) High Supply Air Temp: If the supply air temperature is 5 deg. F. (adj.) greater than set point.
10. Heating Coil Valve: The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its heating set point.
 - a. The heating shall be enabled whenever:
 - 1) Outside air temperature is less than 50 deg. F. (adj.).
 - 2) AND the supply fan status is on.
 - 3) AND the cooling is not active.
 - b. The heating coil valve shall open whenever:
 - 1) Supply air temperature drops from 40 deg. F. to 35 deg. F. (adj.).
 - 2) OR the freezestat is on.
 - c. Alarms shall be provided as follows:
 - 1) Low Supply Air Temp: If the supply air temperature is 5 deg. F. (adj.) less than set point.
11. Heating Coil Freeze Prevention Pump (FZP):
 - a. The recirculation pump shall run whenever the outside air temperature is below 38 deg. F (adj.) or if the freezestat is on.
 - b. Alarms shall be provided as follows:
 - 1) Heating Coil Pump Failure: Commanded on, but the status is off.
 - 2) Heating Coil Pump in Hand: Commanded off, but the status is on.
 - 3) Heating Coil Pump Runtime Exceeded: Status runtime exceeds a user definable limit.
12. Condensing Units: The (DX) cooling system shall be enabled and control discharge air temperature if the campus chilled water system fails or the chilled water temperature rises above set point by 5 deg. F (adj.) for a period of time longer than 15 minutes (adj.).
13. Air Handling Unit Lead/Lag Operation:
 - a. The two (2) variable speed air handling units shall operate in a lead/lag fashion.
 - 1) The lead unit shall run first.
 - 2) On failure of the lead unit, the lag unit shall run and the lead unit shall turn off.
 - b. The designated lead unit shall rotate upon one of the following conditions (user selectable):
 - 1) manually through a software switch
 - 2) if unit runtime (adj.) is exceeded
 - 3) daily
 - 4) weekly
 - 5) monthly

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

c. Alarms shall be provided as follows:

- 1) Failure: Commanded on, but the status is off.
- 2) Running in Hand: Commanded off, but the status is on.
- 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
- 4) AFC Fault.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Supply Duct Air Static Pressure	X							X	X	X
AHU Discharge Static Pressure	X							X	X	X
Supply Fan AFC Speed		X						X		X
Freezestat			X					X	X	X
High Discharge Static Shutdown			X					X	X	X
Low Inlet Static Shutdown			X					X	X	X
Supply Air Smoke Detector			X					X	X	X
Supply Fan AFC Fault			X						X	X
Supply Fan Status			X					X		X
Supply Fan Start/Stop				X				X		X
Supply Air Static Pressure Set point					X			X		X
High Discharge Static Pressure									X	
Low Inlet Static Pressure									X	
Supply Fan Failure									X	
Supply Fan in Hand									X	
Supply Fan Runtime Exceeded									X	
Critical VAV Terminal unit					X					X
Problem VAV Terminal unit					X					X
Heating Coil Pump Start/Stop				X				X		X
Supply Air Temp Set point					X			X		X
Cooling Valve		X						X		X
Heating Valve		X						X		X
Outside Air Temp					X					X
Outside Air Enthalpy					X					X
Emergency Shutdown						X		X	X	X
Heating Coil Pump Failure									X	
Heating Coil Pump in Hand									X	
Heating Coil Pump Runtime Exceeded									X	
Prefilter Change Required									X	X
High Supply Air Temp									X	
Low Supply Air Temp									X	

G. Main Electrical Room Ventilation Air Handling Unit - AHU-5 and CP-3:

1. Run Conditions: The system shall run continuously unless commanded off from the workstation.

2. Supply Fan: The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime. Alarms shall be provided as follows:
 - a. Supply Fan Failure: Commanded on, but the status is off.
 - b. Supply Fan in Hand: Commanded off, but the status is on.
 - c. Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).
3. Supply Air Temperature Set Point:
 - a. The supply air temperature set point shall be 60 deg. F (adj.).
 - b. Reset supply air set point up if VFD is at minimum airflow and the space is below set point.
4. Supply Airflow: The supply fan VFD shall modulate airflow to meet space temperature setting, 80 deg. F (adj.).
5. Cooling Coil Valve:
 - a. The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling set point. The cooling shall be enabled whenever:
 - 1) AND the supply fan status is on.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Supply Fan AFC Speed		X						X		X
Supply Fan AFC Fault			X						X	X
Supply Fan Status			X					X		X
Supply Fan Start/Stop				X				X		X
Supply Fan Failure									X	
Supply Fan in Hand									X	
Supply Air Temp Set point					X			X		X
Cooling Valve		X						X		X
Prefilter Change Required									X	X
High Space Temp									X	

- H. Heat Recovery run-around loop System - HRP-1 and HRP-2 with coils in AHU-1, AHU-2, and HEF-1:
 1. Heat Recovery Pump Run Conditions:
 - a. The heat recovery pumps shall be enabled whenever:
 - 1) AHU-1 and/or AHU-2 are operating.
 - b. The pumps shall run for anytime outside air temperature is less than 55 deg. F. (adj.) and above 75 deg. F. (adj.).
 - c. To prevent short cycling, the pump shall run for a minimum time and be off for a minimum time (both user adjustable).
 2. Heat Recovery Pump Lead/Lag Operation:
 - a. The two (2) variable speed heating recovery pumps shall operate in a lead/lag fashion.
 - 1) The lead pump shall run first.

- 2) On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
- b. The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - 1) manually through a software switch
 - 2) if pump runtime (adj.) is exceeded
 - 3) daily
 - 4) weekly
 - 5) monthly
- c. Alarms shall be provided as follows:
 - 1) Failure: Commanded on, but the status is off.
 - 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) AFC Fault.
3. Heat Recovery Loop Temperature Monitoring:
 - a. The following temperatures shall be monitored:
 - 1) Heat recovery loop supply.
 - 2) Heat recovery loop return.
 - b. Alarms shall be provided as follows:
 - 1) Low Heat Recovery Loop Return to Exhaust Coil Temp: If the heating water supply temperature is less than 34 deg. F. (adj.).
4. AHU three-way Control Valve: The controller shall measure the Heat Recovery Return Temp to exhaust coil and modulate the three-way valve to maintain set point above 38 deg. F (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Heat Recovery Loop Return Temp	X							X		X
Heat Recovery Loop Supply Temp	X							X		X
Heat Recovery Pump AFC Speed *		X						X		X
Heat Recovery Pump Status *			X					X		X
Heat Recovery Pump AFC Fault *			X						X	X
Heat Recovery Pump Start/Stop *				X				X		X
Heat Recovery Pump Failure *									X	
Heat Recovery Pump Running in Hand *									X	
Heat Recovery Pump Runtime Exceeded *									X	
Low Heat Recovery Loop Return Temp									X	
Three-way Control Valves *		X								X

* Point applies to each pump or valve.

I. Air Terminal Units (VAV):

1. Run Conditions - Scheduled:

- a. The BAS shall include three (3) methods for determining space occupancy, Time Of Day (TOD) scheduling, occupancy (OCC) sensors, and Carbon dioxide (CO₂) sensors. Refer to Division 26 for occupancy sensors. Unit shall run according to the occupancy strategy in the following modes:

- 1) Occupied Mode: The unit shall maintain
 - a) A 74 deg. F. (adj.) cooling set point
 - b) A 70 deg. F. (adj.) heating set point.
 - b. Unoccupied Mode (night setback): The unit shall maintain
 - 1) A 85 deg. F. (adj.) cooling set point.
 - 2) A 55 deg. F. (adj.) heating set point.
 - c. Alarms shall be provided as follows:
 - 1) High Zone Temp: If the zone temperature is greater than the cooling set point by a user definable amount (adj.).
 - 2) Low Zone Temp: If the zone temperature is less than the heating set point by a user definable amount (adj.).
2. Zone Set point Adjust: The occupant shall be able to adjust the zone temperature heating and cooling set points at the zone sensor.
3. Zone Unoccupied Override: A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.
4. Reversing Variable Volume Terminal Unit - Flow Control: The unit shall maintain zone set points by controlling the airflow through one of the following:
 - a. Occupied:
 - 1) When zone temperature is greater than its cooling set point, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
 - 2) When the zone temperature is between the cooling set point and the heating set point, the zone damper shall maintain the minimum required zone ventilation (adj.).
 - 3) When zone temperature is less than its heating set point, the controller shall enable heating to maintain the zone temperature at its heating set point. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum heating airflow (adj.) until the zone is satisfied.
 - b. Unoccupied:
 - 1) When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
 - 2) When the zone temperature is greater than its cooling set point, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
 - 3) When zone temperature is less than its unoccupied heating set point, the controller shall enable heating to maintain the zone temperature at the set point. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the auxiliary heating airflow (adj.) until the zone is satisfied.
5. Reheating Coil Valve: The controller shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating set point.
6. Discharge Air Temperature: The controller shall monitor the discharge air temperature.
7. Alarms shall be provided as follows:
 - a. High Discharge Air Temp: If the discharge air temperature is greater than 120 deg. F. (adj.).
 - b. Low Discharge Air Temp: If the discharge air temperature is less than 40 deg. F. (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	X							X		X
Zone Set point Adjust	X									X
Airflow	X							X		X
Discharge Air Temp	X							X		X
Zone Damper		X								X
Reheating Valve		X						X		X
Zone Override			X					X		X
Airflow Set point					X			X		X
Heating Mode						X		X		
Schedule							X			
Heating Set point								X		X
Cooling Set point								X		X
High Zone Temp									X	
Low Zone Temp									X	
High Discharge Air Temp									X	
Low Discharge Air Temp									X	
Zone Occupancy Sensor Override (where applicable)			X			X		X		X
Zone Carbon Dioxide PPM (where applicable)	X							X		X
Zone Time Of Day Schedule Override (where applicable)			X			X		X		X

J. Laboratory airflow Control System (LACS) - HEF-1 and associated Hood Exhaust Valves, Supply Air Valves, General Exhaust Air Valve, and Laboratory Space Controls:

1. Performance/Design Criteria:

- a. Each laboratory shall have a dedicated LACS.
- b. The LACS shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20 percent to 100 percent of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.
- c. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90 percent of its commanded value within one second of the sash reaching 90 percent of its final position (with no more than 5 percent overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.
- d. The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator's presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5 percent overshoot or undershoot.
- e. The LACS shall maintain specific airflow (± 5 percent of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure

- change, airflow change or quantity of airflow control devices on the manifold (within 0.6 inch to 3.0 inch w.c.).
- f. The LACS shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.
 - g. The LACS shall maintain specific airflow (± 5 percent of signal) with a minimum turndown as specified in subparagraph 2. "LACS Operation Sequences" below, to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.
 - h. Airflow Control Sound Specification:
 - 1) The LACS manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.
 - 2) All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.
 - 3) If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the engineer, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.
2. LACS Operation Sequences:
- a. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to occupancy and emergency control commands.
 - b. Volumetric Offset Pressurization Control:
 - 1) The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
 - 2) The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.
 - 3) The pressurization control algorithm shall consider both networked devices, as well as:
 - a) Up to three non-networked devices providing a linear analog flow signal.
 - b) Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.
 - 4) Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.

- 5) The volumetric offset control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.
- c. Temperature Control:
 - 1) Standard Primary Temperature Control:
 - a) The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the BAS, with the option of a local offset adjustment.
 - b) Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
 - 2) Auxiliary Temperature Control: The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop, or staged to supplement the corresponding primary temperature control loop.
- d. Occupancy Control: The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BAS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BAS command.
- e. Emergency Mode Control:
 - 1) The laboratory control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow set point. The system shall support up to four emergency control modes. The emergency control modes may be initiated either by a local contact input or BAS command. Valve level emergency modes can be individually programmed on each valve as one of four emergency control modes. Zone level emergency modes will drive supply and exhaust valves to maintain or ignore zone offset (excludes control of hood valves).
 - 2) Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.
- f. Local Alarm Control: The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as

well as to the BAS. The alarm mask may be configured differently for each room-level system.

g. Fume Hood Control:

- 1) Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:
 - a) Accept command inputs to regulate the flow accordingly and make this command value available to the BAS.
 - b) Accept a sash position signal and make this value available to the BAS.
 - c) Accept a Usage Based Control signal to indicate user presence and make this signal available to the BAS.
 - d) Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BAS.
 - e) Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication.
 - f) The fume hood airflow control device shall respond to changes in sash position and user presence within one second, in order to provide a constant 100-feet-per-minute face velocity when the fume hood is in use.

- h. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BAS communications are carried out reliably. Each laboratory space or pressurization zone shall be its own subnet. Commercially available routers shall be used to provide this isolation.
- i. The LACS shall support at least 20 networked devices in each pressurized zone.
- j. All points shall be available through the interface to the BAS for trending, archiving, graphics, alarm notification and status reports. LACS performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.
- k. Refer to the BAS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

3. Interface To Building Management Systems:

- a. The LACS network shall have the capability of digitally interfacing with the BAS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the LACS supplier.
- b. All room-level points shall be available to the BAS for monitoring or trending as shown in Table 1.

Table 1. Typical Integration Points List

Point Description	Read/Write	Point Description	Read/Write
<i>Valve-Level (per Valve)</i>		<i>Temperature Control (per Zone)</i>	
Flow Set Point	Read Only	Space Temperature	Read Only
Flow Feedback	Read Only	Avg Space Temperature	Read Only
Jam Alarm	Read Only	Discharge Air Temperature	Read Only
Flow Alarm	Read Only	Duct Temperature	Read Only
User Definable Inputs/Outputs	Read/Write	Temperature Set Points (9)	Read/Write
User Definable Alarm Points	Read Only	Effective Temperature Set Point	Read Only
<i>Zone Balance Control (per Zone)</i>		Offset Lever Enable	Read/Write
Occupied Min Ventilation Rate	Read/Write	Offset Lever Percent of Range	Read/Write

Point Description	Read/Write	Point Description	Read/Write
Unoccupied Min Ventilation Rate	Read/Write	Cooling Demand	Read Only
Offset	Read Only	Heating Demand	Read Only
Offset Set Point	Read/Write	Heat Delivered (BTU)	Read Only
MAV Command & Feedback	Read Only	Auxiliary Temp Control Demand	Read Only
GEX Command & Feedback	Read Only	<i>Humidity Control (per Zone)</i>	
Return Command & Feedback	Read Only	Space Humidity	Read Only
Total Zone Supply Flow	Read Only	Humidity Set Point	Read/Write
Total Zone Exhaust Flow	Read Only	Humidity Demand	Read Only
Total Hood Flow Feedback	Read Only	Active Pressure Control (per Zone)*	
Diversity Alarm	Read Only	Zone Pressure	Read Only
<i>Fume Hood Control (per Hood Valve)</i>		Effective Pressure Set Point	Read/Write
Face Velocity	Read Only	Pressure Warning Set Point	Read/Write
Face Velocity Set Point	Read Only	Pressure Alarm Set Point	Read/Write
Sash Opening Percentage	Read Only	Zone Pressure Alarm	Read Only
User Status	Read Only	Sensor Failure Alarm	Read Only
Hood Override Alarm	Read Only	Freeze Mode Time Set Point	Read/Write
Sash Height Alarm	Read Only	Freeze Mode Time Remaining	Read Only
Broken Sash Cable Alarm	Read Only	Freeze Mode Offset Set Point	Read/Write
Sash Switch Status	Read Only	Effective Pressure Control State	Read Only
<i>Emergency Mode (per Zone)</i>			
Emergency Mode Override	Read/Write	* Points are only available on systems using Active Pressure Control	
Emergency Mode State	Read Only		
<i>Occupancy Control (per Zone)</i>			
Occupancy Override	Read/Write		
Occupancy State	Read Only		

- c. LACS critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment or LON FTT-10 bus to a dedicated BACnet MS/TP segment, building BACnet/Ethernet, or BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.
- d. Communication between devices in a room or zone will operate independent of building level communications maintaining integrity of the airflow. LACS Building level communication, or loss of, will not disrupt the communication between devices in a room or zone.
- e. LACS critical environment integration shall provide an easy means to access room level device health status at a room-by-room or building wide level via web page. The system health pages shall provide information to assist in diagnostics for:
 - 1) Online/Offline status for the room level integration appliance.
 - 2) Runtime information such as heap memory usage and CPU usage.
 - 3) Communication channel online/offline and configuration data.
 - 4) Device level online/offline information.
 - 5) Device level alarm information.
 - 6) Device level Configuration errors.
- f. LACS critical environment integration shall provide an easy means to access a Test and Balance function tool at a room-by-room or building wide level via web page. Test and balance functions should include:
 - 1) Setting the devices in the room to various conditions in order to read airflow.
 - 2) Manually override the outputs for testing purposes.
 - 3) Adjust airflow to meet field acceptance tests.
 - 4) Output a report for airflow performance test.

- g. LACS critical environment integration must be able to support SQL database for long term data storage.
 - h. LACS critical environment integration shall provide optional software to manage local backup and restore, entire site device management, building wide test and balance functions, building wide diagnostic tools, and building wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.
4. Hood Exhaust Fan System (HEF-1): consists of three high plume exhaust fans (A, B, & C) mounted on a heat recovery plenum with coil. Hoods on each floor are connected together and each individual floor duct riser is connected to the common exhaust plenum on the roof. The plenum includes bypass control dampers to maintain plume height and inlet plenum static pressure. Provide damper actuators, duct static pressure sensor, and interface with Variable Frequency Drives (VFD) to control fume hood exhaust airflow as described below. Lead-Lag fan designation shall rotate on a periodic basis as scheduled by operations staff.
- a. Bypass dampers shall close and the fans shall be off, if building is designated unoccupied and all chemicals are stored properly.
 - b. Staging ON Fans: During occupied periods the Lead fan "A" shall start and ramp up to minimum speed setting (66 percent of full speed (adj.)) and as required to maintain static pressure set point of negative 2.0-inches (adj.) at the inlet plenum. This setting shall be determined during air balancing and shall be at the lowest practice negative static pressure.
 - c. Once the fan speed reaches 75 percent (adj.) of full flow or above for 10-minutes (adj.), the Lag fan "B" shall start and ramp up to minimum speed setting (66 percent of full speed (adj.)). Both fans shall modulate to maintain negative static pressure set point (adj.). Then start the third fan "C" in the same manner.
 - d. The bypass dampers shall modulate to maintain inlet plenum negative static pressure setting (adj.) anytime the fans are operating at minimum speed and the inlet negative static pressure is 0.5-inches (adj.) above set point.
 - e. Stage fans OFF when all fans are operating at minimum speed and the bypass damper is open 50 percent or greater (adj.) (as determined during air balancing) for more than 10-minutes (adj.).
 - f. Reset minimum fan speed setting based on wind speed as follows:
 - 1) Minimum fan speed = 66 percent at wind speeds between 0 and 20 mph (adj.)
 - 2) Minimum fan speed = 75 percent at wind speeds between 20 and 40 mph (adj.)
 - 3) Minimum fan speed = 100 percent at wind speeds above 40 mph (adj.).
 - g. If any fan stops for any reason or fails to start when called to run by the automation system, the next available fan shall start.
 - h. Safeties: Provide high negative static pressure alarm.
 - i. Provide fan and drive fault alarms.
- K. Process Cooling System - PHX-1, CP-4A, CP-4B, PCP-1A, and PCP-1B:
- 1. Chilled Water Pumps Run Conditions. The chilled water pumps shall be enabled whenever:
 - a. The process pumps are operating.
 - b. The process supply water temperature is above set point.
 - 2. Process Water Pump Run Conditions: The process water pumps shall be enabled through a users defined schedule or manually through the workstation.
 - 3. Alarms and Monitoring:
 - a. Alarms shall be provided as follows:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- 1) Failure: Commanded on, but the status is off.
- 2) Running in Hand: Commanded off, but the status is on.
- 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
- 4) AFC Fault.

b. The following temperatures shall be monitored:

- 1) Process chilled water loop supply.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Process Chilled Water Loop Supply Temp	X							X		X
Heat Recovery Pump Status *			X					X		X
Heat Recovery Pump Start/Stop *				X				X		X
Heat Recovery Pump Failure *									X	
Heat Recovery Pump Running in Hand *									X	

* Point applies to each pump or valve.

L. Kitchen Hood Exhaust - KEF-1:

1. Run Conditions - Scheduled: The fan shall run according to a user definable schedule.
 - a. Fan: The fan shall have a user definable (adj.) minimum runtime.
 - b. Fan Status: The controller shall monitor the fan status. Alarms shall be provided as follows:
 - 1) Fan Failure: Commanded on, but the status is off.
 - 2) Fan in Hand: Commanded off, but the status is on.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Fan Failure									X	
Fan in Hand									X	

M. Central Toilet Exhaust - EF-1:

1. Run Conditions - Scheduled: The fan shall run according to a user definable schedule.
 - a. Fan: The fan shall have a user definable (adj.) minimum runtime.
2. Exhaust Air Damper (where applicable): The exhaust air damper shall open anytime the fan runs and shall close anytime the fan stops. The exhaust air damper shall close 30 sec (adj.) after the fan stops.
 - a. Alarms shall be provided as follows:
 - 1) Damper Failure: Commanded open, but the status is closed.
 - 2) Damper in Hand: Commanded closed, but the status is open.
 - b. Damper Status: The fan shall be enabled after the damper status has proven. Alarms shall be provided as follows:
 - 1) Damper Failure: Commanded open, but the status is closed.
 - 2) Damper in Hand: Commanded closed, but the status is open.

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Cannon Design Project No. 004561.01**

3. Fan Status: The controller shall monitor the fan status. Alarms shall be provided as follows:
 - a. Fan Failure: Commanded on, but the status is off.
 - b. Fan in Hand: Commanded off, but the status is on.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Exhaust Air Damper (where applicable)				X				X		X
Fan Failure									X	
Fan in Hand									X	

- N. Ventilation Fans - VF-1 (L0 Mech Rm), VF-2 (L1 Elev. Control Rm), VF-3 (L1 AV Control Rm), and VF-4 (Mech Rm):
 1. Run Conditions - Scheduled: The fan shall run according to a user definable schedule.
 - a. Fan: The fan shall have a user definable (adj.) minimum runtime.
 - b. Zone Temp: If the zone temperature is above set point 80 deg. F (adj.) by a user definable amount (adj.) the fan shall start.
 2. Fan Air Damper (where applicable): The air damper shall open anytime the fan runs and shall close anytime the fan stops. The exhaust air damper shall close 30 sec (adj.) after the fan stops.
 - a. Alarms shall be provided as follows:
 - 1) Damper Failure: Commanded open, but the status is closed.
 - 2) Damper in Hand: Commanded closed, but the status is open.
 - b. Damper Status: The fan shall be enabled after the damper status has proven. Alarms shall be provided as follows:
 - 1) Damper Failure: Commanded open, but the status is closed.
 - 2) Damper in Hand: Commanded closed, but the status is open.
 3. Fan Status: The controller shall monitor the fan status. Alarms shall be provided as follows:
 - a. Fan Failure: Commanded on, but the status is off.
 - b. Fan in Hand: Commanded off, but the status is on.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Fan Status			X					X		X
Fan Start/Stop				X				X		X
Exhaust Air Damper (where applicable)				X				X		X
Fan Failure									X	
Fan in Hand									X	

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- O. Data Closet Cooling Systems - FCU-1/ACCU-2, FCU-2/ACCU-2, FCU-3/ACCU-3, FCU-4/ACCU-4, and FCU-5(A/B/C)/ACCU-5:
1. Run Conditions - The systems shall operate using factory furnished controls to maintain set point of 80 deg. F. (adj.). The BAS shall monitor space temperature and alarm if out of range.
 2. High Zone Temp Alarm: If the zone temperature is above set point by a user definable amount (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	X							X		X
High Zone Temp									X	

- P. Space Heating Units - Unit Heaters (UH), Cabinet Unit Heater (CUH), and Overhang Soffit Heating - Fin Tube Radiation (FTR):
1. Run Conditions - The unit shall run to maintain a heating set point of 65 deg. F. (adj.).
 2. Low Zone Temp Alarm: If the zone temperature is less than the heating set point by a user definable amount (adj.).
 3. Fan (where applicable): The fan shall run anytime the zone temperature drops below heating set point, unless shutdown on safeties.
 4. Heating Coil Valve: The controller shall measure the zone temperature and open the heating coil valve to maintain its heating set point. The heating shall be enabled whenever outside air temperature is less than 65 deg. F. (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	X							X		X
Zone Set point Adjust	X									X
Fan Start/Stop				X				X		X
Heating Valve				X				X		X
Heating Set point								X		X
Low Zone Temp									X	

- Q. Perimeter Heating - Fin Tube Radiation (FTR):
1. Run Conditions: The perimeter FTR shall operate when outside air temperatures are below 50 deg. F. (adj.) with an outside air OA reset function.
 2. Perimeter FTR Draft Barrier Heating: The Space/Zone VAV units shall control to space set point as described in "Air Terminal Units (VAV)" sequence above. When the outside air temperatures are below 50 deg. F. (adj.) the perimeter heating FTR valve shall modulate open on an OA reset from 0 to 100 percent (adj.) based on OA temperatures between 50 to 10 deg. F. (adj.). The perimeter FTR heating valve shall fully close once space temperature rises to within 2 deg. F. (adj.) of any associated VAV unit cooling set point in order to avoid simultaneous heating and cooling.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
OA Temp	X							X		X
FTR Reset Adjust	X									X
Heating Valve				X				X		X
Heating Set point								X		X

3.10 FIRE-SMOKE DAMPERS

- A. Provide and install fire-smoke dampers as specified in Section 238800, as indicated on drawing, and as required to meet codes. Dampers shall close upon a detection of smoke by a duct mounted smoke detector. Coordinate with fire alarm system for connections and operations.

3.11 MONITORING AND ALARM OF VARIOUS SYSTEMS

- A. Provide interface to available remote monitoring system or connections to available alarm contacts at equipment and display equipment status and alarm failures for the following systems:
 - 1. Sump Pumps SP-1 and SP-2 duplex (foundation drain):
 - a. Pump run status.
 - b. High water alarm.
 - 2. Elevator Sump Pumps ESP-1 and ESP-2 (two separate pumps):
 - a. High water alarm.
 - 3. Level 0 Sump Pump, SP-3 (condensate floor drains):
 - a. High water alarm.
 - 4. Electric Meter to Building:
 - a. The meter has available an Ethernet port and a Serial RS485 port that supports Modbus protocol.
 - b. Provide interface and display voltage and amperage for each phase and kWh and frequency.
 - 5. Standby Generator and Automatic Transfer Switches:
 - a. Status
 - 6. ISB Chilled Water Supply and Return Temperatures.
 - 7. Lighting Controls/Schedules:
 - a. Building interior lighting.
 - b. Zone/space lighting.
 - c. Exterior lighting.
 - 8. Vacuum Pump and Air Compressor Systems: Provide the following alarms from equipment isolated contact:
 - a. Vacuum pump "Reserve Unit Alarm"
 - b. Vacuum pump "High Discharge Temperature Shutdown"
 - c. Air compressor "Reserve Unit Alarm"
 - d. Air compressor "High Discharge Temperature Shutdown"

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INDEX

DIVISION 23 – MECHANICAL WORK

SECTION 239900 – TESTING, ADJUSTING AND BALANCING

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL TESTING AND BALANCING REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		2
2.1	GENERAL	2
PART 3 - EXECUTION		2
3.1	EXAMINATION	2
3.2	DEFICIENCIES	2
3.3	GENERAL PROCEDURES FOR TESTING AND BALANCING	2
3.4	GENERAL PROCEDURES FOR TESTING AND BALANCING AIR SYSTEMS	3
3.5	PROCEDURES FOR VARIABLE AIR VOLUME SYSTEMS	4
3.6	GENERAL PROCEDURES FOR HYDRONIC SYSTEMS	5
3.7	PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS	6
3.8	PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS	6
3.9	PROCEDURES FOR MOTORS	6
3.10	PROCEDURES FOR CONDENSING UNITS	6
3.11	PROCEDURES FOR BOILERS	6
3.12	PROCEDURES FOR HEAT TRANSFER COILS	6
3.13	PROCEDURES FOR COMMERCIAL KITCHEN HOODS	7
3.14	PROCEDURES FOR LABORATORY FUME HOODS	7
3.15	PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS	8
3.16	REPORTING	9
3.17	FINAL REPORT	9

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SECTION 239900 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 REFERENCES

- A. Division 01, GENERAL REQUIREMENTS and all requirements of Section 230100 - BASIC MECHANICAL REQUIREMENTS, apply to the work under this specification section.

1.2 GENERAL TESTING AND BALANCING REQUIREMENTS

- A. A test and balance firm certified by either AABC or NEBB shall perform all required testing and balancing work. Balancing work shall be performed in accordance with the procedures set forth by NEBB or AABC. Test and Balance Report shall contain seal of certified test and balance Contractor.
- B. Work shall be performed under direct supervision of a certified heating and air conditioning technician. Instruments used shall be accurately calibrated with seal indicating calibration within 6 month period and maintained in good working order.
- C. Balancing shall not begin until systems have been completed, pressure tested, and are in full working order. The systems shall be in full operation during balancing period. When project phasing results in partial Owner occupancy, perform test and balance procedures for occupied portions of the project as each phase is completed. When subsequent phases of work affect previously balanced portions of the project, re-balance those systems. Coordinate schedule of test and balance work with the Owner.
- D. Contractor shall include in his proposal an extended warranty period of 90 days during which time the Engineer, at his discretion, may request a recheck or resetting of any air or water flow rate or pressure regulating valve. Contractor shall provide assistance of the proper trades to assist Engineer in making any tests or adjustments.

1.3 SCOPE OF WORK

- A. The work under this specification section includes the following:
 - 1. Testing and balancing of air distribution system
 - 2. Testing and balancing of hydronic systems
 - 3. Certified and sealed submittal reports
 - 4. Laboratory fume hood airflow balancing
 - 5. Space pressurization testing and adjusting
 - 6. Sound level measuring

1.4 DESCRIPTION OF SYSTEMS

- A. See related specification sections for outline of systems under this contract.

1.5 SUBSTITUTIONS

- A. Not applicable.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 230100. Provide Test and Balance Report as specified in PART 3 of this section.
 - 1. Product Data: For paints, including printed statement of VOC content and chemical components.
- B. LEED Submittal:
 - 1. Air-Balance Report for Prerequisite EQ 1: Documentation of air balancing work performed according to ASHRAE 111 or SMACNA's "HVAC Systems – Testing, Adjusting and Balancing."

2. Product Data for Credit EQ 4.2: For paints, including printed statement of VOC content and chemical components.

PART 2 - PRODUCTS

2.1 GENERAL

- A. There are no products associated with this section except those that are needed to execute work as described in PART 3.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements. Examine the Article SEQUENCE OF OPERATIONS in Section 239500 of these specifications to become familiar with the designed system controls.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine system and equipment installations to verify that they are complete and ready for testing and balancing work.
- D. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing.
- E. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- F. Examine terminal units to verify that they are accessible and their controls are connected and functioning.

3.2 DEFICIENCIES

- A. Report deficiencies in the installation or performance of a system or component discovered before and during performance of Test and Balance procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- B. Retest the deficiencies after all work necessary to correct deficient items has been completed and verified by the affected Contractor.
- C. Note all unresolved deficiencies in the final report.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", and this Section.
- B. Total outside airflow and space airflow shall be balanced according to ASHRAE 111 or SMACNA's "HVAC Systems – Testing, Adjusting, and Balancing."
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by renovation work.
- D. Tolerances: Set HVAC system airflow and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: 0 to plus 10 percent.
 2. Air Outlets and Inlets: 0 to minus 10 percent.
 3. Heating Hot Water Flow Rate: 0 to minus 10 percent.

4. Chilled Water Flow Rate: 0 to minus 5 percent.
 5. Supply and Exhaust for Laboratories: plus 5 to minus 5 percent of room offset.
- E. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to Section 232500.
- F. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
1. Paints applied to interior ferrous metal substrates shall not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.
- G. Take and report testing and balancing measurements in inch-pound (IP) units.
- 3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING AIR SYSTEMS
- A. Preparation:
1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
 2. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
 3. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 4. Check dampers for proper position to achieve desired airflow path.
 5. Check for airflow blockages.
- B. Fans:
1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 2. Test and record fan motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
- C. Air Handling Equipment:
1. Measure static pressure across each component that makes up an air handling unit, rooftop unit, and other air handling equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 2. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
- D. Volume Dampers:
1. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - a. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

- 1) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 - b. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- E. Diffusers and Grilles:
 1. Measure terminal outlets and inlets without making adjustments.
 - a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
 2. Adjust terminal outlets and inlets for each space to indicated airflows. Make adjustments using volume dampers rather than the dampers at air terminals.
 - a. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - b. As applicable, at least one zone balancing damper shall be completely open. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.

3.5 PROCEDURES FOR VARIABLE AIR VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. After the fan systems have been adjusted, adjust the variable air volume systems as follows:
 1. Set outside air dampers at minimum, and return and exhaust air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return air ducts and inlets.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record the final fan performance data.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - 1. Open all manual valves for maximum flow.
 - 2. Check expansion tank liquid level.
 - 3. Check makeup water station pressure gage for adequate pressure for highest vent.
 - 4. Check flow-control valves for specified sequence of operation and set at indicated flow.
 - 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 - 6. Set system controls so automatic valves are wide open to heat exchangers.
 - 7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 - 8. Check air vents for a forceful liquid flow exiting from vents when manually operated.
- C. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
 - 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 - 4. Report flow rates that are not within plus or minus 5 percent of design.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 - 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 - 1. Determine the balancing station with the highest percentage over indicated flow.
 - 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 - 3. Record settings and mark balancing devices.
- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor air temperature.
- I. Measure the differential-pressure control valve settings existing at the conclusion of balancing.

3.7 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.8 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

- A. Balance the primary system crossover flow first, and then balance the secondary system.

3.9 PROCEDURES FOR MOTORS

- A. Motors, 1/2 horsepower and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer, model, and serial numbers.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable Frequency Drives: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering and leaving air temperatures.
- C. Record compressor data.

3.11 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering and leaving water temperatures and water flow.
- B. If steam, measure entering water temperature and flow and leaving steam pressure, temperature, and flow.

3.12 PROCEDURES FOR HEAT TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering and leaving water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Electric Heating Coils: Measure the following data for each coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering and leaving air temperature at full load.
 - 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 - 5. Calculated kilowatt at full load.
 - 6. Fuse or circuit breaker rating for overload protection.

C. Refrigerant Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.13 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

- A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
1. Install welded test ports in the sides of the exhaust duct for the duct Pitot tube traverse. Install each test port with a threaded cap that is liquidtight.
- B. After balancing is complete, do the following:
1. Measure and record the static pressure at the hood exhaust duct connection.
 2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
 3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.
- C. Visually inspect the hood exhaust duct throughout its entire length in compliance with Authorities Having Jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.
1. Check duct slopes as required.
 2. Verify that duct access is installed as required.
 3. Verify that point of termination is as required.
 4. Verify that duct air velocity is within the range required.
 5. Verify that duct is within a fire-rated enclosure.
- D. Report deficiencies.

3.14 PROCEDURES FOR LABORATORY FUME HOODS

- A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.
- B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.
1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
 2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow.
- C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

- D. After balancing is complete, do the following:
1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
 2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening.
 - a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
 - b. Calculate and report the average face velocity by averaging all velocity measurements.
 - c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
 - d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.
 3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.
- E. Laboratory Hood Control Testing
1. All lab doors should remain closed during testing.
 2. No lab work should be in progress during testing.
 3. Record values from fume hood monitors after readings are stabilized. Note if values are not stable.
 4. Keep traffic minimized inside the lab while measurements are being taken.
 5. Record color of indicating lights on fume hood monitor.
 6. Directly measure and record exhaust airflow at each hood exhaust valve.
 7. Directly measure and record differential pressure across each hood exhaust valve.
 8. Directly measure and record the exhaust duct static pressure upstream of all exhaust devices.
 9. Directly measure and record supply airflow at each supply air valve.
 10. Directly measure and record differential pressure across each supply air valve.
- F. With the room and laboratory fume hoods operating at indicated conditions perform an "as-installed" performance test of the laboratory fume hood according to ASHRAE 110. Test each laboratory fume hood and document the test results.

3.15 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

- A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
- C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.

2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
 3. Test room pressurization first, then zones, and finish with building pressurization.
- D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.
- E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
 2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
 3. For spaces served by variable air volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.
- F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.
- G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.16 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.17 FINAL REPORT

- A. General: Typewritten or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
1. Pump curves
 2. Fan curves
 3. Manufacturers' test data
 4. Field test reports prepared by system and equipment installers
 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
1. Title page
 2. Name and address of TAB firm

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

3. Project name
 4. Project location
 5. Architect's name and address
 6. Engineer's name and address
 7. Contractor's name and address
 8. Report date
 9. Signature of TAB firm who certifies the report
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report
 11. Summary of contents including the following:
 - a. Indicated versus final performance
 - b. Description of system operation sequence if it varies from the Contract Documents
 12. Data for terminal units, including manufacturer, type and size
 13. Notes to explain why certain final data in the body of reports varies from indicated values
 14. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside, return, and exhaust air dampers
 - b. Conditions of filters
 - c. Cooling coil, wet and dry-bulb conditions
 - d. Face and bypass damper settings at coils
 - e. Fan drive settings including settings and percentage of maximum pitch diameter
 - f. Settings for supply air, static-pressure controller
 - g. Other system operating conditions that affect performance
- E. Air-Handling Unit Test Reports:
1. Unit Data: Include the following:
 - a. Unit identification
 - b. Location
 - c. Make and type
 - d. Model number and unit size
 - e. Manufacturer's serial number
 - f. Unit arrangement and class
 - g. Discharge arrangement
 - h. Sheave make, size in inches, and bore
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches
 - j. Number of belts, make, and size
 - k. Number of filters, type, and size
 2. Motor Data:
 - a. Make and frame type and size
 - b. Horsepower and rpm
 - c. Volts, phase, and Hertz
 - d. Full-load amperage and service factor
 - e. Sheave make, size in inches, and bore
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm
 - b. Total system static pressure in inches w.g.
 - c. Fan rpm
 - d. Discharge static pressure in inches w.g.
 - e. Filter static pressure differential in inches w.g.
 - f. Preheat coil static pressure differential in inches w.g.
 - g. Cooling coil static pressure differential in inches w.g.
 - h. Heating coil static pressure differential in inches w.g.
 - i. Outside airflow in cfm

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- j. Return airflow in cfm
 - k. Outside air damper position
 - l. Return air damper position
 - m. Vortex damper position
- F. Heat Transfer Coil Test Reports:
- 1. Coil Data:
 - a. System identification
 - b. Location
 - c. Coil type
 - d. Number of rows
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number
 - g. Face area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm
 - b. Average face velocity in fpm
 - c. Air pressure drop in inches w.g.
 - d. Outside air, wet and dry-bulb temperatures in deg. F.
 - e. Return air, wet and dry-bulb temperatures in deg. F.
 - f. Entering air, wet and dry-bulb temperatures in deg. F.
 - g. Leaving air, wet and dry-bulb temperatures in deg. F.
 - h. Water flow rate in gpm
 - i. Water pressure differential in feet of head or psig
 - j. Entering water temperature in deg. F.
 - k. Leaving water temperature in deg. F.
 - l. Refrigerant expansion valve and refrigerant types
 - m. Refrigerant suction pressure in psig
 - n. Refrigerant suction temperature in deg. F.
 - o. Inlet steam pressure in psig
- G. Fan Test Reports: For supply, return, relief, and exhaust fans, include the following:
- 1. Fan Data:
 - a. System identification
 - b. Location
 - c. Make and type
 - d. Model number and size
 - e. Manufacturer's serial number
 - f. Arrangement and class
 - g. Sheave make, size in inches, and bore
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches
 - 2. Motor Data:
 - a. Make and frame type and size
 - b. Horsepower and rpm
 - c. Volts, phase, and Hertz
 - d. Full-load amperage and service factor
 - e. Sheave make, size in inches, and bore
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches
 - g. Number of belts, make, and size
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm
 - b. Total system static pressure in inches w.g.
 - c. Fan rpm

- d. Discharge static pressure in inches w.g.
 - e. Suction static pressure in inches w.g.
- H. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air handling unit number
 - b. Location and zone
 - c. Traverse air temperature in deg. F.
 - d. Duct static pressure in inches w.g.
 - e. Duct size in inches
 - f. Duct area in sq. ft.
 - g. Indicated airflow rate in cfm
 - h. Indicated velocity in fpm
 - i. Actual airflow rate in cfm
 - j. Actual average velocity in fpm
 - k. Barometric pressure in psig
- I. Air Terminal Device Reports:
 - 1. Unit Data:
 - a. System and air handling unit identification
 - b. Location and zone
 - c. Test apparatus used
 - d. Area served
 - e. Air terminal device make
 - f. Air terminal device number from system diagram
 - g. Air terminal device type and model number
 - h. Air terminal device size
 - i. Air terminal device effective area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm
 - b. Air velocity in fpm
 - c. Preliminary airflow rate as needed in cfm
 - d. Preliminary velocity as needed in fpm
 - e. Final airflow rate in cfm
 - f. Final velocity in fpm
 - g. Space temperature in deg. F.
- J. System Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air handling unit identification
 - b. Location and zone
 - c. Room or riser served
 - d. Coil make and size
 - e. Flowmeter type
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm
 - b. Entering water temperature in deg. F.
 - c. Leaving water temperature in deg. F.
 - d. Water pressure drop in feet of head or psig
 - e. Entering air temperature in deg. F.
 - f. Leaving air temperature in deg. F.

- K. Compressor and Condenser Reports: For refrigerant side of unitary systems, standalone refrigerant compressors, or air-cooled condensing units, include the following:
1. Unit Data:
 - a. Unit identification
 - b. Location
 - c. Unit make and model number
 - d. Compressor make
 - e. Compressor model and serial numbers
 - f. Refrigerant weight in pounds
 - g. Low ambient temperature cutoff in deg. F.
 2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches w.g.
 - b. Outlet-duct static pressure in inches w.g.
 - c. Entering air, dry-bulb temperature in deg. F.
 - d. Leaving air, dry-bulb temperature in deg. F.
 - e. Control settings
 - f. Unloader set points
 - g. Low-pressure cutout set point in psig
 - h. High-pressure cutout set point in psig
 - i. Suction pressure in psig
 - j. Suction temperature in deg. F.
 - k. Condenser refrigerant pressure in psig
 - l. Condenser refrigerant temperature in deg. F.
 - m. Oil pressure in psig
 - n. Oil temperature in deg. F.
 - o. Voltage at each connection
 - p. Amperage for each phase
 - q. Kilowatt input
 - r. Crankcase heater kilowatt
 - s. Number of fans
 - t. Condenser fan rpm
 - u. Condenser fan airflow rate in cfm
 - v. Condenser fan motor make, frame size, rpm, and horsepower
 - w. Condenser fan motor voltage at each connection
 - x. Condenser fan motor amperage for each phase
- L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
1. Unit Data:
 - a. Unit identification
 - b. Location
 - c. Service
 - d. Make and size
 - e. Model and serial numbers
 - f. Water flow rate in gpm
 - g. Water pressure differential in feet of head or psig
 - h. Required net positive suction head in feet of head or psig
 - i. Pump rpm
 - j. Impeller diameter in inches
 - k. Motor make and frame size
 - l. Motor horsepower and rpm
 - m. Voltage at each connection
 - n. Amperage for each phase
 - o. Full-load amperage and service factor

- p. Seal type
- 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig
 - b. Pump shutoff pressure in feet of head or psig
 - c. Actual impeller size in inches
 - d. Full-open flow rate in gpm
 - e. Full-open pressure in feet of head or psig
 - f. Final discharge pressure in feet of head or psig
 - g. Final suction pressure in feet of head or psig
 - h. Final total pressure in feet of head or psig
 - i. Final water flow rate in gpm
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- M. Boiler Test Reports:
 - 1. Unit Data:
 - a. Unit identification
 - b. Location
 - c. Service
 - d. Make and type
 - e. Model and serial numbers
 - f. Fuel type and input in BTUh
 - g. Number of passes
 - h. Ignition type
 - i. Burner-control types
 - j. Voltage at each connection
 - k. Amperage for each phase
 - 2. Test Data (Indicated and Actual Values):
 - a. Operating pressure in psig
 - b. Operating temperature in deg. F.
 - c. Entering water temperature in deg. F.
 - d. Leaving water temperature in deg. F.
 - e. Number of safety valves and sizes in NPS
 - f. Safety valve settings in psig
 - g. High-limit setting in psig
 - h. Operating-control setting
 - i. High-fire set point
 - j. Low-fire set point
 - k. Voltage at each connection
 - l. Amperage for each phase
 - m. Draft fan voltage at each connection
 - n. Draft fan amperage for each phase
 - o. Manifold pressure in psig
- N. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:
 - 1. Date and time of test. Record each tested location on its own NC curve
 - 2. Sound meter manufacturer, model number, and serial number
 - 3. Space location within the building including floor level and room number
 - 4. Diagram or color photograph of the space showing the measurement location
 - 5. Time weighting of measurements, either fast or slow
 - 6. Description of the measured sound: steady, transient, or tonal

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- 7. Description of predominant sound source
- O. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make
 - b. Serial number
 - c. Application
 - d. Dates of use
 - e. Dates of calibration

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 260000 – ALTERNATES

Article	Title	Page
PART 1 - GENERAL		1
1.1	RELATED DOCUMENTS.....	1
1.2	GENERAL REQUIREMENTS.....	1
1.3	SCOPE OF WORK.....	1
PART 2 - PRODUCTS		1
2.1	ALTERNATES	1
PART 3 - EXECUTION		1
3.1	MANUFACTURER'S STANDARDS.....	1
3.2	RELATED WORK	1

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SECTION 260000 - ALTERNATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. All provisions of Division 01, GENERAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL REQUIREMENTS

- A. Bids submitted by Contractor shall state the amount to be added to or deducted from the base bid for the following alternate(s) if accepted.

1.3 SCOPE OF WORK

- A. Bidder shall make certain that he understands the scope of each alternate and shall evaluate all resulting additions, deletions and alterations to all affected work and shall include the cost of all such factors including all overhead and profit in his proposal for each alternate.

PART 2 - PRODUCTS

2.1 ALTERNATES

- A. Proprietary differences between base bid products and alternate products are allowable; however; functions, ratings, safety devices, and other requirements of base bid equipment, device or system shall be included in each alternate bid.
 - 1. Alternate E1: Indicate the contract amount to be added to or deducted from the base bid for providing an alternate lighting control system as described in specification Section 265700 in lieu of specified Unified Lighting Control System.

PART 3 - EXECUTION

3.1 MANUFACTURER'S STANDARDS

- A. Alternate products or systems shall be installed according to manufacturer's recommendations and related auxiliary components required by specific manufacturer shall be provided.

3.2 RELATED WORK

- A. Other work affected by this alternate shall be included in Contractor's bid as required to provide a coordinated fully operating equipment, device or system.

END OF SECTION 260000

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 260100 – BASIC ELECTRICAL REQUIREMENTS

Article	Title	Page
PART 1	GENERAL.....	1
1.1	REFERENCES	1
1.2	GENERAL REQUIREMENTS.....	2
1.3	SCOPE OF WORK.....	3
1.4	DESCRIPTION OF SYSTEMS	4
1.5	SUBSTITUTIONS	4
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	4
1.7	SHORT CIRCUIT AND PROTECTIVE DEVICE AND ARC FLASH STUDIES	6
1.8	LIST OF MANUFACTURERS FOR MATERIAL AND EQUIPMENT	9
1.9	MATERIALS AND WORKMANSHIP	10
1.10	CONTRACTOR'S SUPERVISION AND SUBCONTRACT WORK	10
1.11	COORDINATION	10
1.12	SITE OBSERVATION	11
1.13	PERMITS AND INSPECTIONS	11
1.14	TRADE AND LOCAL PRACTICES	11
1.15	TEMPORARY FACILITIES.....	11
1.16	CUTTING AND PATCHING.....	12
1.17	ORAL INSTRUCTIONS TO OWNER	13
1.18	MOUNTING AND LOCATIONS	13
1.19	RECORD DRAWINGS	14
1.20	MAINTENANCE MANUALS	15
1.21	FINAL OBSERVATION	16
1.22	TESTING.....	16
1.23	GUARANTEE	17
1.24	SUBMITTAL SUMMARY	17
PART 2	PRODUCTS (NOT USED).....	17
PART 3	EXECUTION (NOT USED).....	17

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SECTION 260100 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCES

- A. All provisions of GENERAL CONDITIONS and Sections in Division 01, GENERAL REQUIREMENTS, govern work under this specification division.
- B. References to standards of organizations are made herein in accordance with the following abbreviations:

ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guideline
AEIC	Association of Edison Illuminating Companies
AIA	The American Institute of Architects
ANSI	American National Standards Institute Inc.
ASA	American Standards Association
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
BMA	BACnet Manufacturer's Association
BOCA	Building Officials and Code Administrators International, Inc.
CBEMA	Computer and Business Equipment Manufacturers Association
CBM	Certified Ballast Manufacturers Association
CPD	Construction Products Directive (CE Mark)
EEL	Edison Electrical Institute
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EPA	Environmental Protection Administration
ETL	Electrical Testing Laboratories Inc.
FCC	Federal Communications Commission
FHWA	Federal Highways Administration
FIA	Factory Insurance Association
FM	Factory Mutual Research Corp.
IAEI	International Association of Electrical Inspectors
ICBO	International Conference of Building Officials (UBC Sponsors)
ICEA	Insulated Cable Engineers Association
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
ISO	International Standard Organization
LEED	Leadership in Energy and Environmental Design
LPI	Lightning Protection Institute
MFMA	Metal Framing Manufacturers Association
NAECA	National Appliance Energy Conservation Act 1988
NEC	National Electrical Code (NFPA 70)
NEMA	National Electrical Manufacturer's Association
NFAC	National Fire Alarm Code (NFPA 72)
NFPA	National Fire Protection Association
NESC	National Electric Safety Code
NICET	National Institute of Certified Engineering Technicians
OSHA	Occupational Safety and Health Administration
SBC	Standard Building Code
UL	Underwriters Laboratories, Inc.
WTA	William Tao & Associates, Inc.

- C. Work installed shall be in strict compliance with governing codes and regulations. Installation shall be in accordance with installation recommendations and details provided by product manufacturers unless exceeded in quality by these specifications. Work called for in the specifications or shown on the drawings that is deemed contrary to the code by the local authority having jurisdiction governing shall be brought to attention of Engineer prior to rough-in for clarification or revision.

1.2 GENERAL REQUIREMENTS

- A. See Division 01.
- B. WTA Computer Aided Design (CAD) Drawings in Electronic Format:
 - 1. Computer Aided Design (CAD) drawings in electronic format when provided under this contract shall be for the convenience of the recipient only. The CAD drawings were prepared as William Tao & Associates, Inc. internal working documents. Depending on how the drawings are utilized and reassembled the resulting CAD drawings may be incomplete, contain inaccuracies or be in part obsolete. Therefore, William Tao & Associates, Inc. makes no representation as to its completeness, currency or accuracy.
 - 2. The user is advised that any translation of CAD drawings from one computer system or environment to another can and often does result in the loss of important data. This loss can include but may not be limited to: portions of text and dimensions - The existence, location or scale of symbols or other elements of graphics - The internal structure of the data including layers and data attributes - The style or weight of lines. William Tao & Associates, Inc. makes no representations as to the usability of this CAD data on any system.
 - 3. The user is further warned that, while all digital CAD data appears to be extremely accurate, this apparent accuracy is an artifact of the techniques used to generate it and is in no way intended to imply actual accuracy. The user of this data takes full responsibility for the accuracy and correctness of all measurements, areas, inventories, etc. extracted from this data either manually or with the use of a computer.
- C. First-Named Manufacturer:
 - 1. First-named manufacturer's device, equipment or system has been used in specifications and drawings to meet the job requirements and to determine the space and dimensional requirements. Verify that devices, equipment, systems or products by other than the first-named manufacturer used as basis for proposal will meet the job requirements and will fit the allocated space.
 - 2. Listing of a manufacturer as acceptable does not in any way relieve the Contractor from the responsibility for providing a device, equipment or system that meets the requirements of the specifications.
 - 3. No extra cost will be allowed due to effect on other trades when bid is based on products other than first-named manufacturer. Contractor shall be responsible for coordination required for the use of substituted devices, equipment, systems, or products by other than the first-named manufacturer.
- D. Drawing Details: Since the installation of devices, equipment and systems may vary by each manufacturer and the "approved manufacturer" for the job was unknown at the time the drawing details were made, the details shown on the drawings are to be accepted by the Contractor as general in nature and are not to be used for their installation. Contractor shall obtain from the "approved manufacturer" of the devices, equipment or systems detailed installation drawings for their proper installation.
- E. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter.

Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.

- F. Submission of shop drawings will be considered as indicating that space requirements have been reviewed and that submitted equipment will fit space allocated with due concern given to access required for maintenance purposes.
- G. Contract drawings and specifications are complementary and what is called for by one shall be as binding as if called for by both.
- H. Contractor shall furnish all labor and material required to complete installation including accessories, fittings, auxiliaries, and components required for proper performance of systems.
- I. "Provide" as called for in the specifications or on the drawings shall mean, "furnish and install."
- J. Location of Equipment and Devices:
 - 1. Locations of the electrical equipment and devices shown are approximate. Determine the exact location of the equipment and devices by checking the Architectural Drawings, or the approved shop drawings.
 - 2. Relocate equipment or devices when directed by Architect/Engineer without cost, providing equipment has not been installed and the new location is not greater than 10 ft. from the location shown.
- K. Do not scale drawings. Refer to Architectural and Structural Drawings for new building construction, dimensions and finishes in order to provide proper rough-in and installation of work.
- L. Quality Control:
 - 1. Exposed Work in Finished Spaces: Install electrical devices and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed.
 - 2. Equipment Access: Install electrical devices and equipment to facilitate servicing, maintenance and repair or replacement. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.
 - 3. Cleanliness: Contractor shall keep debris and dirt from around, on top of and the inside of all electrical equipment he provides during construction.
- M. Campus Medium Voltage: Contractor shall include in his bid all labor and material required for connection of the new building into the existing campus medium voltage distribution system during other than normal working hours.

1.3 SCOPE OF WORK

- A. Provide labor, material, mounting hardware, terminations, tools, transportation, services, and equipment necessary to provide complete and operating systems for work specified in Division 26. See individual sections for Scope of Work and Division 01. Following general items shall be included as part of required work.
 - 1. Secondary unit substation.
 - 2. 600V switchboards and microprocessor metering.
 - 3. SPD on main service switchboard.
 - 4. SPD on selected panelboards.
 - 5. Dry-type transformers.
 - 6. Busway.
 - 7. Panelboards.
 - 8. Automatic transfer switches (ATS).
 - 9. Disconnect switches.
 - 10. Fuses.
 - 11. Conduits, surface raceway and wireway.
 - 12. Medium-voltage conductors, terminations, and tests.
 - 13. Low-voltage conductors and terminations.

14. Receptacles, switches, and wall plates.
15. Vibration and seismic control requirements.
16. Lighting fixtures, lamps and time switch and photocontrol.
17. Occupancy sensors, time switch, relays, contactors, and photocontrol.
18. Engine/generator, remote alarm annunciator (RAA) and skid tank.
19. Lightning protection.
20. Grounding.
21. Power wiring to mechanical, plumbing and fire protection equipment.
22. Power wiring for elevators and special equipment.
23. Fire alarm system.
24. All miscellaneous wiring, conduit, accessories and devices to result in a complete electrical system.

- B. See Division 01, LEED REQUIREMENTS, for requirements including, but not limited to construction IAQ management plan.

1.4 DESCRIPTION OF SYSTEMS

- A. See individual sections of Division 26 for general description of required electrical systems, equipment, devices and products.

1.5 SUBSTITUTIONS

- A. See Division 01.
- B. Reference related Division 26 sections of specifications for additional requirements.
- C. Submit to Architect/Engineer a typed list of substitutes proposed to be used in lieu of the device, equipment or system named in specifications or drawings with a request for approval of the proposed substitutes. List and written requests with detailed information shall be delivered to office of Architect/Engineer not later than 10 days prior to bid due date to be considered for approval. Submittal shall include following:
1. Specific device, equipment or system proposed for substitution giving manufacturer, catalog and model number.
 2. Performance and dimensional data necessary for comparison of proposed substitute with equipment or material specified.
- D. When the Contractor does not provide the written request for substitutions, the Contractor shall be required to provide one of the listed manufacturers in the specifications or on the drawings.
- E. Samples shall be provided when requested by Engineer. Samples shall be delivered to office of Engineer with transportation charges prepaid. Supplier will be notified and shall cause sample to be removed from office of Engineer in unpacked condition at completion of Engineer's examination of product. Samples not removed after 30 days will be discarded.
- F. Addenda for proposed substitutes that are found to be acceptable will be issued by Architect/Engineer. Architect/Engineer reserves right to reject substitutes which are inferior in quality, capacity or design, or which adversely affect overall concept. Decision of Architect/Engineer shall be final.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Division 01, LEED REQUIREMENTS for preliminary submittal, progress reports and submittal documentation requirements.
- B. Shop drawings shall be submitted in accordance with Division 01 related articles of GENERAL CONDITIONS and with the requirements of this article.
- C. See article entitled SUBMITTAL SUMMARY and detailed shop drawing requirements in other sections of Divisions 26. Submittal transmittal shall reference specification section and description of equipment. Submittals shall be clearly scheduled and marked as to which model number, quantity and type is being submitted. Copies of catalog cut sheets are not sufficient

unless clearly defined project specific information is marked. All shop drawings submitted shall include the WTA project number and project name that is given in the drawing title block. Shop drawings that are resubmitted shall be noted as resubmittals and shall be given same WTA log number, as original submittal, suffixed by A or B as applicable. Shop drawing shall include the specification section that the submittal item is referencing. Each specification section shall be submitted as a single submittal, otherwise will be rejected.

- D. Contractor must allow 2 weeks for Engineers to review and process the shop drawings. Shop drawings shall be phased and submitted in a sequence, which allows adequate time for Engineer review. Submittal of large numbers of shop drawings simultaneously is discouraged and may result in time for review, which exceeds the normal 2 week commitment for return. Any effect on construction schedule due to untimely submittal of shop drawings shall be the responsibility of the Contractor. Contractor shall submit Electrical Submittal Summary within 2 weeks of being awarded the contract.
- E. All shop drawings shall be submitted in a legible manner. Submittals shall be original or first generation. Any submittals that have been recopied to the point of illegible status will be rejected. Submittals must be in PDF format.
- F. All electronic shop drawing submittals shall be emailed to "**wtashop@wmtao.com Attention: Sara Trout.**" Please include password/rights when sending shop drawings to wtashop if done through an informational exchange site.
- G. Shop drawings and product data of standard cataloged products shall be submitted with applicable data that meet the job requirements. Submittals that include information on multiple devices or equipment are acceptable only when items applicable to the job are identified with arrows, check marks or other call outs. Schedules shall be submitted in legible form as stated above. Schedules shall be not less than double spaced to allow for corrections by Engineer. Manufacturer's submitted literature, catalogs or bulletins covering equipment shall be submitted with schedules in quantity called for under Division 01 and under GENERAL CONDITIONS. Printed material shall also be included in Maintenance Manual.
- H. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter. Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.
- I. Shop drawings are required for equipment, material and devices scheduled in Submittal Summary. Shop drawings of related equipment, devices and material shall be submitted at same time so Architect/Engineer can coordinate related components.
- J. Incomplete submittals and submittals not in accordance with above paragraphs will be returned without action, and resubmittal will be required.
- K. Corrections or modifications made by Architect/Engineer shall be deemed acceptable with no change in the contract amount unless written notice is received by the Architect/Engineer prior to the performance of the work affected by the corrections or modifications.
- L. Review and stamp shop drawings in accordance with requirements of GENERAL CONDITIONS prior to submittal to Architect/Engineer. Shop drawings without Contractor's stamp will be returned without checking.
- M. No material or equipment shall be released for manufacture or shipment without first obtaining the Architect/Engineer's approved shop drawings.
- N. When shop drawings are created from or incorporated with the Engineer's CAD drawings, the Contractor shall remove the Architect and Engineer's title block and reinsert the Contractor's title block. The new title block shall include the Contractor's name, address and telephone number, the project name and the name of the Architect/Engineer of record. Reference

preceding GENERAL REQUIREMENTS Article 1.2 in this Section for the contents of the CAD drawings in electronic format provided by WTA.

- O. Submittal Summary: See SUBMITTAL SUMMARY at end of this specification section.

1.7 SHORT CIRCUIT AND PROTECTIVE DEVICE AND ARC FLASH STUDIES

- A. General: The Contractor shall provide complete short circuit, protective device coordination and arc flash studies as soon as possible. Contractor shall employ an independent testing service to provide the short circuit, protective device coordination and arc flash studies. The independent testing service shall contact Webster University and obtain their relay settings and/or available short circuit current and transformer impedance and provide coordination. The studies shall include all portions of the electrical distribution system from the utility 5 kV service(s) to the primary service switchgear, unit substation primary switches, down to and including each switch or circuit breaker in each switchboard, motor control center, automatic transfer switch, and panelboard throughout each system. All system connections and those which result in maximum fault conditions shall be adequately covered in the study. Coordination plots shall be provided for each primary and secondary distribution system.
- B. Components of Study: The studies shall include:
 - 1. Relay and fuse characteristics
 - 2. The base kVA quantity selected
 - 3. Impedance source data
 - 4. Calculation methods and tabulations
 - 5. One-line diagrams
 - 6. A ground fault study for each primary and secondary system.
 - 7. Short circuit momentary duties, when applicable, and interrupting duties calculated on the basis of an assumed fault at each 5 kV feeder to the transformer switchgear assembly, low voltage switchboard, motor control center, automatic transfer switch and panelboard throughout each system. This shall include all possible configurations between main and tie protective devices on all double ended or busway connected unit substations.
 - 8. The short circuit tabulations shall include the fault impedances, X to R ratios, asymmetry factors, kVA, symmetrical and asymmetrical fault currents.
 - 9. Conclusions and recommendations.
- C. Approval:
 - 1. The complete short circuit, protective device coordination and arc flash studies shall be submitted to the Consulting Engineer with or preceding 5 kV and 600 volt distribution equipment shop drawings. This will help prevent manufacture of equipment not suitable for a safe installation.
 - 2. If completion of the short circuit, protective device coordination and arc flash studies would cause delay in manufacturer of any equipment, approval from the Consulting Engineer may be obtained by providing a preliminary submittal of sufficient study data to prove that the selection of the protective device's interrupting capacity and coordination with other devices and bus bracing of the equipment will be satisfactory. However, a complete formal report must still be submitted in its entirety as soon as possible for approval by the Consulting Engineer.
- D. Study Report Submittal:
 - 1. The results of the short circuit, protective device coordination and arc flash studies shall be summarized in a final report. Six (6) bound copies of the final report shall be submitted.
 - 2. The report shall include the following sections:
 - a. Short circuit calculations including a definition of terms and guide for interpretation of computer printout.
 - b. Description, purpose, basis and scope of the study and a single diagram of that portion of the power system which is included within the scope of the study.

- c. Tabulations of all relays, circuit breakers and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
 - d. Protective device time versus current coordination curves, tabulations of all relay settings, fuse selections, ground fault settings, and commentary regarding same.
- E. Contract Drawing and Specifications: The drawings and specifications indicate the general requirements for the motors, motor starting equipment, primary voltage, secondary voltage equipment, and other equipment.
 - 1. Additional specific characteristics of the equipment furnished shall be determined from the equipment proposed for installation on the project; equipment installed shall be in accordance with the results of the short circuit, protective device coordination and arc flash studies.
 - 2. Any equipment design discrepancies and any proposed corrective modifications, if required, shall be submitted with the short circuit, protective device coordination and arc flash studies with any variations clearly noted.
 - 3. Necessary field settings, adjustments and minor modifications for conformance with the approved short circuit, protective device and arc flash settings determined by the coordination study shall be accomplished by the Contractor under the direction of the equipment manufacturer's field engineer.
- F. Short Circuit Study:
 - 1. The study input data shall include Webster University's Campus short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.
 - 2. The short circuit study may be prepared with a network analyzer, a digital computer or by written calculations, but shall include complete fault calculations as hereinbefore specified for each proposed and ultimate source combination. It should be noted that source combinations shall include all proposed and future service feeders, large motors or generators.
 - 3. Short circuit momentary duty values and interrupting duty values shall be calculated on the basis of assumed 3 phase bolted short circuits at bus on each of the following:
 - a. Unit substation metal-enclosed primary switch
 - b. Secondary switchgear
 - c. Low voltage switchboard
 - d. Motor control center
 - e. Automatic transfer switch
 - f. Distribution panelboard
 - g. Branch circuit panelboard
 - h. Other significant locations throughout each system

The short circuit tabulations shall include symmetrical fault currents and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.
- G. Protective Device Coordination Study:
 - 1. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage fuse ratings and circuit breaker trip characteristics and settings. The objective of the study is to obtain optimum protective and coordination performance from these devices. Protective relay settings and fuses shall be set to trip or open prior to operation of campus relays or fuses.
 - 2. Plots shall include complete titles, representative one-line diagrams and legends, fuse and relay characteristics, associated campus relay characteristics, significant motor starting characteristics, complete parameters of substation transformers, complete operating bands for secondary voltage switchgear circuit breaker trip curves and fuses.

3. Graphically indicate the coordination proposed for the several systems centered on full scale Keuffel and Esser log-log paper.
 4. Coordination plots shall indicate the types of protective devices selected.
 5. Indicate for the long time region, a complete tap scale for each medium voltage relay, full load current and 150, 400 or 600 percent full load current transformer parameters and designate the pickups required for the secondary voltage circuit breakers.
 6. Indicate for the short time region, the medium voltage relay instantaneous elements, the magnetizing inrush and withstand transformer parameters, the secondary voltage circuit breaker, short time and instantaneous trip devices, fuse manufacturing tolerance bands, secondary voltage fuses, significant symmetrical and asymmetrical fault currents, and other pertinent information.
 7. All restrictions of the NEC shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.
 8. The selection and settings of all protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connection, manufacturer and type, range of adjustment and recommendations. Power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas, or inadequacies shall be promptly brought to the Consulting Engineer's attention in writing.
 9. Metal Clad Service Switchgear: Where possible the protective relays shall be separated by a minimum of 0.4 seconds between the relay's curve and the curve of any protective device on the line side of protective relay.
 10. Unit Substations:
 - a. Each primary protective device required for a delta-to-wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which shall include a parameter equivalent to 58 percent of the withstand point to afford protection for secondary line-to-ground faults. The transformer damage curve shall be included for each transformer when the selected protective device is not within the associated parameters. Where possible the primary fuse shall be separated by a minimum of 0.1 second between the fuses total clearing curve and a line side relay curve.
 - b. Secondary voltage power circuit breakers shall be separated from each other and the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line-to-line faults.
 11. Transformer: Each primary protective device required for a delta-to-wye connected transformer shall be selected so the characteristic or operating band is within the transformer parameters. The transformer damage curve shall be included for each transformer when the selected protective device is not within the associated parameters.
 12. Main Switchboard: Secondary voltage circuit breakers shall be separated from the associated primary protective device by a 16 percent current margin for coordination and protection in the event of secondary line-to-line faults.
- H. Protective Device Evaluation Study:
1. A protective device evaluation study shall be performed to determine the adequacy of all protective relays, circuit breakers, fuses, and switches, and automatic transfer switches, by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents in the short circuit study.
 2. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. Any problem areas or inadequacies in the equipment specified due to short circuit currents shall be promptly brought to the Consulting Engineer's attention in writing.

I. Arc Flash Hazard Analysis:

1. An arc flash hazard analysis shall be performed according to IEEE 1884. This analysis shall be performed in conjunction with the short circuit and time-current coordination studies.
2. The flash protection boundary and incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor control centers, panelboards and busway) where work could be performed on energized parts.
3. Where multiple potential operating scenarios exist, multiple calculations shall be performed and compared and the greatest incident energy shall be presented for each equipment location.
4. Calculations shall be performed using maximum and minimum available fault current.
5. Arc Flash calculations shall be based on total clearing time of the actual overcurrent protective device. A maximum clearing time of 2 seconds shall be used based upon IEEE 1584-2002 except where it is not physically possible to move outside of the arc flash protection boundary in less than 2 seconds. In those instances the maximum clearing time shall be based on the specific location.
6. Report: Provide the results of the study in tabular form. Tabulation shall include bus name and protective device name, bolted fault and arcing fault current levels, arc flash boundary, working distance, incident energy and personal protective equipment classes. The report may also include recommendations to reduce arc flash incident energy levels.
7. Labels:
 - a. Provide labels in accordance with specification Section 261950 - ELECTRICAL IDENTIFICATION.
 - b. Labels shall include the following information:
 - 1) Flash Hazard Boundary
 - 2) Arc Flash incident energy level
 - 3) Personal Protective Equipment category
 - 4) System Voltage
 - 5) Limited, Restricted, and Prohibited Approach Boundaries
 - c. After approval by Owner and Architect/Engineer, Contractor shall install labels as follows:
 - 1) Floor Standing Equipment: Place a label on the front of each individual section. On equipment requiring side and rear access, place a label on each section access area.
 - 2) Wall Mounted Equipment: Place labels on the front cover or nearby adjacent surface.

J. Approved Independent Testing Services: The following are approved Independent Testing Services:

Mr. Larry Fortier
(847) 608-6788
Fortier Testing & Sales
228 Will Scarlett Ln.
Elgin, IL 60120

Mr. Steve Reed
(314) 890-9999
Electric Power Systems
15 Millpark Ct.
Maryland Heights, MO 63043

Mr. Robert Ross
(816) 525-7156
Electrical Reliability Services
348 NW Capital Dr.
Lee's Summit, MO 64086

1.8 LIST OF MANUFACTURERS FOR MATERIAL AND EQUIPMENT

- A. Submit List of Material and Equipment within 4 calendar weeks after award of contract by Owner. Provide six (6) copies to Architect/Engineer for approval of the manufacturers of material and equipment proposed for project.
- B. Approval of the shop drawings will be subject to the submission of material and equipment by the manufacturers shown on this list.
- C. Provide the first-named manufacturer for material and equipment on project if the "List of Material and Equipment" is not received by the Architect/Engineer within the prescribed time

limit, or if the specified equipment or material is not listed on the submitted list. Reference preceding GENERAL REQUIREMENTS Article 1.2 in this section for first-named manufacturer requirements.

1.9 MATERIALS AND WORKMANSHIP

- A. Material and equipment required under this contract shall be new unless otherwise specified. Workmanship shall be first class and be performed by persons qualified in respective trades.
- B. Material shall meet requirements of governing codes and regulations.
- C. Electrical material, equipment and systems, where applicable, shall be UL listed.

1.10 CONTRACTOR'S SUPERVISION AND SUBCONTRACT WORK

- A. Work shall be under constant supervision of qualified superintendent or foreman.
- B. Submit name of major subcontractors to Owner for approval prior to award of subcontract work. Owner reserves right to approve or disapprove major subcontractors.
- C. Job superintendents or foremen shall not be changed without prior notice to and approval of Owner in order to maintain proper coordination and continuity of branches of work.

1.11 COORDINATION

- A. Coordinate work to eliminate interferences. Interferences due to lack of coordination shall be corrected to provide proper clearance and access with costs borne by Contractor. Electrical equipment shall not be hung from piping or ductwork or from hangers supporting piping or ductwork. Install conduit and boxes giving right-of-way where space is available to systems such as plumbing, drain and fire protection lines required to be installed at a specified slope.
- B. All electrical equipment, without exception, shall be installed with adequate space and working clearances as required by the NEC. In addition, clearances shall be maintained to allow for access, repairs and removal of equipment and devices. Protect installation of equipment or devices from being obstructed by other equipment, piping, etc. installed by other contractors on the project.
- C. Contractor shall prepare drawings for installation of equipment, devices and systems as required by Division 01 to coordinate work. Joint coordination drawings by Contractors shall be prepared as a joint effort to coordinate installation of work by the affected trades. These drawings are not to be submitted to the Architect/Engineer for approval.
- D. Permanent openings or knockout panels shall be provided to permit future service or replacement of system components, but not necessarily for entry or exit of entire assembled units. Coordinate equipment delivery with construction progress in order that installation may be made in orderly and safe manner.
- E. Contractor shall provide arrangements for hoisting equipment and assume related cost. Routes used by hoisting vehicles and vehicle parking shall be approved by Owner prior to their use.
- F. Building structure is designed for supporting equipment at its permanent location. Provide necessary shoring or other protection necessary for moving heavy equipment to permanent location.
- G. Top elevations indicated for site related work shall be considered approximate only. Coordinate final grades and elevations prior to installation and completion of work affected by final grade elevations. Work installed that does not meet finished grades shall be adjusted at no increase in contract amount.
- H. Contractor shall coordinate his equipment delivery with construction progress in order that installation may be made in an orderly and safe manner.

1.12 SITE OBSERVATION

- A. Visit site prior to preparation of bid and determine conditions that affect execution of work.
- B. Locations and elevation of existing underground utilities, such as manholes and poles, sewers, water piping, duct banks, cables, and conduits are as exact as can be determined from available information and their accuracy cannot be guaranteed. Exact location and elevation of these services shall be verified by Contractor prior to excavation or installation of work. Exercise special care when excavating at or near the general location of underground utilities to avoid damage to utility services, as well as to assure safety. Existing utility services damaged due to operation of Contractor shall be repaired to satisfaction of Owner at Contractor's expense.
- C. Connections to or relocation of existing utility lines requiring temporary discontinuation of utility services that are in active use shall be scheduled and coordinated with Representatives of Owner. Services shall not be left disconnected at end of working day or weekend unless authorized by representatives of Owner. Existing utility services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.
- D. Failure to be acquainted with existing conditions under which work is to be performed will not be justification for additional compensation.
- E. Missouri 1-800-DIG-RITE: Missouri law requires the Contractor to call Missouri One Call System Inc. (MOCS) not more than 10 days in advance of any excavation activity unless it's an emergency situation involving danger to life, health or property.

1.13 PERMITS AND INSPECTIONS

- A. Obtain required permits governing the contract work from Authorities Having Jurisdiction and assume cost of permits and inspections.
- B. Furnish to Owner certificates of observation or approval from Authorities Having Jurisdiction, if certificates of observation or approval are required by law or regulations, upon completion of work.
- C. Contractor shall assume the cost of labor and materials to conduct all required acceptance tests required by Local Code Enforcing Authority.

1.14 TRADE AND LOCAL PRACTICES

- A. Comply with local customs and labor trade agreements regarding trade or trades that shall be employed for installation of work.

1.15 TEMPORARY FACILITIES

- A. See Division 01.
- B. Temporary Light and Power for Construction:
 - 1. Provide temporary service arranged to serve lighting and power requirements for construction.
 - 2. Temporary electrical work shall be installed and removed in accordance with latest NEC.
 - 3. Electric service shall be derived from Contractor's own generators and transformers. Coordinate temporary service with. Method of terminating and running electric service shall be reviewed with Owner and shall commence at time agreeable to Owner.
 - 4. Contractor shall provide his own generators, transformers and distribution panels where existing circuits are not available.
 - 5. System feeders shall originate from approved electrical distribution panels.
 - 6. Electric energy used for temporary power and light will not be metered. Electrical energy cost will be paid by Owner.
 - 7. Branch circuits used for temporary power shall be protected in raceway or cable assembly and terminate on 20 amperes ground fault circuit interrupter (5 mA) personnel

type circuit breakers or on GFCI (5 mA) personnel type duplex receptacles. Personnel protected type power shall be provided so that no part of new building or structure is more than 50 ft. from 120 volts duplex outlet or 100 ft. from 208 volts outlet.

8. Minimum of one lighting outlet with lamps shall be provided for every 500 sq. ft. of building area, at stairways between floors and every 30 ft. in corridors. Lamps shall be protected from accidental contact or breakage. Lamps shall be 100 to 300 watt incandescent or two (2) 40 watt fluorescents. Individual rooms shall have at least one light regardless of size. Lighting shall be maintained. Lighting service shall be provided during normal workday 8:00 a.m. to 4:00 p.m. and during nighttime hours if required for security or safety.
9. Extension cords for power and additional lighting, if required, will be responsibility of individual Subcontractor involved.
10. Branch circuits for temporary lighting and receptacles shall not be terminated on the same branch circuit protective device or share a common neutral conductor.
11. Contractor shall remove temporary lights when permanent lighting facilities have been placed in operation.
12. Temporary facilities shall be removed at completion of project.

1.16 CUTTING AND PATCHING

- A. See Division 01.
- B. General: Structural members and load-bearing walls or footings shall not be cut without first obtaining written permission from Architect/Engineer. Openings shall be core drilled or cut as applicable.
- C. Cutting:
 1. Openings for conduit and cable in masonry materials shall be core drilled. Other openings shall be cut as necessary. See Section 260500, SLEEVES AND OPENINGS article for additional details.
 2. Make thorough investigation and field measurement by use of magnetic detection instruments or other approved means to detect concealed ferrous metal piping or conduit prior to cutting. Active piping, conduit or wire damaged due to this work shall be restored immediately. Restoration costs shall be at the expense of the Contractor.
 3. Cutting shall be limited to size necessary for working conditions.
- D. Patching and Finishing:
 1. Patching:
 - a. Concrete or Concrete Block Surfaces: Patch opening with grout finished smooth with adjacent surface prior to applying final finish.
 - b. Gypsum Board or Plastered Surfaces: Patch opening with filler compound finished smooth with adjacent surface prior to applying final finish.
 - c. Special Finished Surfaces: Patch openings with appropriate material where surfaces are to have finishes such as glazed tile, paneling, stone or marble finish.
 - d. Painted Surfaces: Patch opening smooth with adjacent surfaces.
 2. Finishing:
 - a. Where surfaces have received their final finish prior to being cut or where the surface of an existing finish is cut, Contractor shall refinish surfaces to match the adjacent surfaces.
 - b. Contractor requiring the cutting shall be responsible for the quality of the finish work and make corrections to the refinished surfaces to maintain the quality of the finish to match the existing finish.
 - c. Maintain the watertight integrity of all penetrations of roofs or exterior walls and floors on or below grade.

1.17 ORAL INSTRUCTIONS TO OWNER

- A. See Division 01.
- B. Assign responsible person who is thoroughly familiar with installed systems to give verbal instructions to Owner's assigned operating personnel whenever systems are turned over to Owner for operation.
- C. Direct specific instructions by factory-trained representatives shall be provided for following equipment and systems in addition to above general instructions.
 - 1. Specialty systems (and equipment)
 - 2. Engine generator(s) and associated controls
 - 3. Automatic transfer switch(es)
 - 4. Fire alarm system

1.18 MOUNTING AND LOCATIONS

- A. Location of Equipment and Devices:
 - 1. Locations of electrical equipment and devices shown are approximate. Determine exact location by checking Architectural Drawings, and approved shop drawings.
 - 2. Relocate equipment or devices when directed by Architect/Engineer without cost, provided equipment has not been installed and new location is not greater than 10 ft. from location shown.
 - 3. Duplex power receptacles, telephone outlets, data processing outlets or other system outlets within room shall be located at same height, and of same vertical configuration.
 - 4. Wiring, signal and control devices shall be flush mounted in finished areas.
- B. Mounting Heights: Mounting heights shall be to center of device's outlet box unless otherwise indicated by existing conditions or Architect/Engineer details. Mounting height of devices and equipment shall comply with following schedules.
 - 1. Wiring Devices:
 - a. Light Switches (wall mounted)4'-0" above floor
 - b. Light Switches (wall mounted)
at obstruction.....3'-8" above floor
 - c. Receptacles (finished areas).....1'-6" above floor
 - d. Receptacles (unfinished areas).....4'-0" above floor
 - e. Washer and Drier Outlets4'-0" above floor
 - 2. Miscellaneous Devices:
 - a. Pushbutton Stations4'-0" above floor
 - b. Contactors or Controllers.....4'-0" above floor
 - c. Dimmer Switches or Controls
(wall mounted).....4'-0" above floor
 - 3. Fire Alarm Devices:
 - a. Manual Stations.....4'-0" above floor
 - b. Signal Devices (wall mounted).....Not less than 6'-8"
and not greater than 8'-0"
above the finished floor
 - c. Annunciator and Control PanelSee drawings
 - 4. Power Equipment:
 - a. Disconnect Switches, Contactors
and Time Switches.....4'-0" above floor
 - b. Starters (individually mounted).....4'-0" above floor
 - c. Panelboards or Relay Panels.....See drawings

1.19 RECORD DRAWINGS

- A. See Division 01.
- B. Contractor shall provide Record Drawings to Owner within 90 days after the date of system acceptance.
- C. Contractor shall keep day-to-day record of the installed items as follows:
 - 1. Location of conduit concealed in walls, floors, underground, or above inaccessible ceilings. Record need not include exposed conduit or conduit above removable ceilings.
 - 2. Sizes and location of all feeders and their conduits changed from those shown on the original set of Contract Drawings issued for construction.
 - 3. Location of pull and junction boxes for power and control systems.
 - 4. All changes (additions or deletions) in branch circuit and feeder identifications (circuit numbers and/or load descriptions) different from those shown on the original set of Contract Drawings issued for construction. Panelboard directories shall be up-dated with the final load descriptions and circuit numbers that match those shown on the Record Drawings.
 - 5. Location of smoke detectors in air duct systems.
 - 6. Location of underground cable, and conduit, duct banks, and electric utilities exterior of building.
 - 7. Location of underground utility services, both inside and outside of buildings, shall be dimensioned from permanent structures or bench mark. Utility services outside of buildings shall show depth of burial with reference to finished grade.
 - 8. Lighting branch circuits and their associated remote control devices. This applies to lighting controlled by contactors, relays, time switches, photocontrols or programmable control systems.
 - 9. Location of engine/generator(s), day tank(s), charger(s), and associated equipment in engine/generator room or space. Reference Section 266500, STANDBY POWER ENGINE/GENERATORS article for additional requirements.
 - 10. Changes in all columns of the equipment data, panelboard and lighting fixture schedules to reflect those items as installed.
 - 11. Reference Division 27 for record drawing requirements for voice, data and CATV system.
- D. Underground utility services, both inside and outside of buildings, shall be dimensioned from permanent structures or benchmark. Utility services outside of buildings shall show depth of burial or flow line with reference to finished ground floor elevation.
- E. Contractor shall obtain a set of drawing prints of the Contract Drawings pertaining to his work immediately upon commencing work on project. This set of drawings shall be kept at the project site at all times and be used by the Contractor for manually recording the changes in the Contract Drawings. These drawings shall be kept as clean as possible and all marks for record purposes shall be legible. This will help the Contractor in the preparation of Record Drawings. Should a single print or drawing become crowded or unclear due to excessive changes at any time prior to the completion of the project, the Contractors shall obtain a second copy of the same drawing and make additional manual recordings as necessary. Both drawings shall be retained at the job site.
- F. CAD Drawings: One set of Engineering Contract Document drawings in electronic format will be issued to the Construction Manager or General Contractor at start of construction. One additional set of Engineering Drawings in electronic format will be issued to the Construction Manager or General Contractor prior to date of Substantial Completion. Reference previous GENERAL REQUIREMENTS Article 1.2 for the contents of the CAD drawings in electronic format provided by WTA. Any copies of these documents requested by the Contractors or subcontractors shall be provided by the Construction Manager or General Contractor. Contractor shall transfer the projects record conditions recorded on job site prints, as outlined above, to the CAD drawings. No other electronic file updates will be provided by the Architect/Engineer.

- G. Contractor shall obtain a copy of CAD drawings in electronic format from WTA on a disk. Reference previous GENERAL REQUIREMENTS Article 1.2 for contents of CAD drawings provided by WTA. Contractor shall use this disk to prepare Record Drawings. Record Drawings shall be made by using Revit MEP 2015 compatible system and deliver disk plus one set of reproducible drawings and two (2) sets of full size drawings to Architect/Engineer for approval prior to authorization for final payment. Record Drawings shall be certified as to their correctness by signature of Contractor and shall be stamped or otherwise identified as "RECORD DRAWINGS."
- H. When final revisions have been completed by the Contractor, the cover sheet drawing shall show the wording "RECORD DRAWINGS" followed by the name of the authenticating Contractor and project completion date in letters minimum 1/8 inch high. The Contractor shall mark all other contract drawings "RECORD DRAWINGS" along with a stamp/signature and project completion date in the specified authentication area provided on each drawing.

1.20 MAINTENANCE MANUALS

- A. See Division 01.
- B. Contractor shall provide maintenance Manuals to Owner within 90 days after the date of system acceptance.
- C. General: Contractor shall provide three (3) hard copy volumes of Maintenance Manuals and a CD of all material submitted at completion of project. Manuals shall be provided one week prior to Contractor's request for final observation. Manuals that include information on multiple systems are acceptable only when items not applicable to the system installed are crossed out.
 - 1. Startup and Shutdown Procedures: Provide step-by-step write up of major equipment. Incorporate manufacturer's printed startup, troubleshooting and shutdown procedures.
 - 2. Equipment List: Provide list of major equipment as installed. engine/generator(s), ATSS, transformers, switchgear, switchboards, panelboards, lighting fixtures, poles, termination kits, and fire alarm equipment shall include manufacturer, model number, ampacities, and nameplate data.
 - 3. Service Instructions: Provide following information:
 - a. Recommended spare parts including catalog number and name, address and telephone number of local suppliers or factory representatives.
 - b. Lubrication and maintenance instructions for equipment including electric motors.
 - c. Maintenance and operating instructions for circuit breakers, switches, relays and other components associated with main service switchgear. Maintenance and operating instructions for special systems; i.e., fire alarm, engine/generators, fuel tanks, annunciators, transfer switches, and similar systems requiring routine attention.
 - d. Document Safety: Related work practices, procedures, and arc flash protective equipment for Owner employees and/or Contractors who work on or near exposed energized electrical equipment as required by the latest NFPA-70 E.
 - 4. Include in manuals, parts catalogs for items of equipment furnished with components identified by number for replacement ordering.
- D. Submission:
 - 1. Manuals shall be in triplicate, and materials shall be neatly bound into volumes of standard 8-1/2 inch x 11 inch hard binders. Large drawings too bulky to be folded into 8-1/2 inch x 11 inch size shall be separately bound or folded into brown envelopes, cross-referenced and indexed with manuals. A CD shall be included with all material submitted.
 - 2. Manuals shall include name of Architect/Engineer and all Contractors.
 - 3. It is suggested that The Contractor submit one preliminary copy of manual to Engineer for precheck; and when approved, shall submit three (3) final hard copies and one CD through normal channels.

1.21 FINAL OBSERVATION

- A. See Division 01.
- B. Contractor shall review requirements of Contract Documents, observe work and inform parties involved of work to be corrected or completed before project can be deemed substantially complete.
- C. Notify Architect/Engineer in writing, when project is substantially complete listing those items of work remaining incomplete and anticipated date that remaining work will be completed. Final observation of project will then be scheduled by Architect/Engineer.
- D. Architect/Engineer reserves right to cancel and re-schedule observation in event considerable more work remains to be completed or corrected than indicated in written request for observation.
- E. Representative of Contractor shall be present at Engineer's and Owner's final observation.
- F. Items not completed or found not complying with drawings or specifications by Architect/Engineer will be identified in observation report by Architect/Engineer.
- G. Copy of final observation report will be given to Contractor. Deficient items on observation report shall be corrected. Contractor shall initial and date items on report after corrections have been completed.
- H. Owner will make final check after items have been corrected. Contractor shall be present during final check and shall verify that corrections have been made.

1.22 TESTING

- A. General:
 - 1. Contractor shall be responsible for providing tests, and record of tests to Architect/Engineer and Authority Having Jurisdiction. Testing shall be performed by and under direct supervision of Contractor and shall be made only by qualified personnel fully experienced in this type of testing.
 - 2. Contractor shall provide necessary test equipment. Checking of factory wiring and other preliminary work in preparing for electrical tests shall be responsibility of Contractor.
 - 3. Tests shall be scheduled with Owner and manufacturer's representative. Testing shall be during normal working hours unless otherwise indicated or specified.
 - 4. Contractor shall correct faults, malfunctions or failures discovered during tests. Faulty equipment or devices shall be replaced with new equipment or devices provided by Contractor. Replaced equipment or devices shall be retested after replacement to verify their correct operation. When the equipment or device is part of a system, the system shall be retested to verify its correct operation.
 - 5. Reference Section 014100, TESTING AND INSPECTION SERVICES for additional details.
- B. Tests:
 - 1. Tests are to ensure that workmanship, methods, observations, and materials used in installation of equipment and systems conform to accepted engineering practices, electrical specifications and manufacturer's instructions.
 - a. Visual test
 - b. Operational test
 - c. Acceptance test for FINAL OBSERVATION
 - 2. Visual Test: Perform visual observation of equipment and connections at job site prior to operational test to prevent damage to equipment and harm to testing personnel.
 - 3. Operational Startup Test:
 - a. Contractor shall make preliminary operational startup test at job site and provide certified test reports to Architect/Engineer prior to FINAL OBSERVATION.

- b. Test reports of operational startup tests identified with complete data of readings, observations, and actions taken, shall be made into report for systems or piece of equipment tested. Provide minimum of three (3) test reports for each test to Architect/Engineer.
 - 4. Acceptance Test: Acceptance test shall be run on selected devices and equipment during FINAL OBSERVATION. Acceptance will be determined by Architect/Engineer after reviewing preliminary operational startup test reports and equipment performance during operational test at job site. Final operational tests shall be performed on selected electrical equipment to show that equipment will correctly perform required functions.
- C. Specific Tests: Field or job site tests shall be performed and test reports made for approval by Architect/Engineer for each of the following. An indexed binder with a copy of all of the tests shall be submitted to the Architect/Engineer for record prior to final observation by the Architect/Engineer and final payment by the Owner. Refer to specific articles in sections indicated for specific test requirements.
 - 1. 5kV cables (Section 261100)
 - 2. 600 Volt Feeders (Section 261200)
 - 3. Power Transformers (Section 264000)
 - 4. Unit Substations (Section 264000)
 - 5. Automatic Transfer Switches (Section 264000)
 - 6. Ground Fault Protection System (Section 264000)
 - 7. Dry-Type Transformers (Section 264000)
 - 8. 600 Volt Busway (Section 264000)
 - 9. Grounding Electrode System (Section 264500)
 - 10. Lighting Fixture Adjustment and Testing (Section 265100 or 265200)
 - 11. Low Voltage Control Switching System (Section 265700)
 - 12. Standby Power System Startup and Acceptance Tests (Section 266500)
 - 13. Fire Alarm (Section 267100)

1.23 GUARANTEE

- A. General Guarantee:
 - 1. Guarantee work against defects in labor and material for period of one year from date of Owner acceptance and Owner's takeover of equipment for use and maintenance.
 - 2. Starting date of guarantee for defective or incomplete system or equipment shall become effective only after correction of defects and completion of systems or equipment.
 - 3. Guarantee period for systems or equipment will begin from date of correction and completion. Submit written certificate in triplicate listing such systems and equipment to Architect/Engineer for signature of Owner for record purposes. Certificate for partial use of systems or equipment will become effective after being countersigned by Owner.
 - 4. Guarantee is not intended to cover damage resulting from Owner's misuse or to cover normal maintenance.
- B. Specific Warranty: See specific equipment specification for warranties extended beyond one year. Provide manufacturer's warranty of subject equipment to Owner prior to receiving final payment where warranties are specified. Warranties shall cover labor, material and travel expenses to repair and place equipment back in operation.

1.24 SUBMITTAL SUMMARY

- A. See the following Submittal Summary forms at the end of this section of specifications for detailed list of minimum submittal requirements.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

ELECTRICAL SUBMITTAL SUMMARY

Spec. Section No.	Description of Submittal	Catalog Cuts	Plan, Elevations and Details	Wiring Diagrams	Bound Test Reports	Schedule of Items	Requested Samples	Maintenance Manual	WTA Review Period (Weeks)	Contractor Estimated Submittal Date*	Furnish as Submitted	Furnish as Noted	Revise and Resubmit	Rejected	Other
260100	Maintenance Manuals	X		X	X			X	4						
260100	Test				X				2						
260100	Short Circuit and Protective Device and Arc Flash Study				X				2						
260500	Firestop Systems	X							2						
261100	Conductors Above 600 Volts and Tests	X			X				2						
261100	Connectors Above 600 Volts	X							2						
261200	Conductors to 600 Volts and Tests	X			X				2						
261200	Connectors to 600 Volts	X							2						
261300	Conduit	X							2						
261300	Surface Metal Raceway	X							2						
261400	Wiring Devices and Cover Plates	X				X	X		2						
261950	Nameplates	X					X		2						
261950	Cable Tags	X							2						
261950	Buried Warning Tape	X							2						
262400	Seismic Detail Report by Registered PE	X	X		X	X			4						
262400	Type of Isolation	X			X				2						
262400	Seismic Snubbers	X			X				2						
264000	Secondary Unit Substations and Tests	X	X	X	X			X	2						

ELECTRICAL SUBMITTAL SUMMARY

Spec. Section No.	Description of Submittal	Catalog Cuts	Plan, Elevations and Details	Wiring Diagrams	Bound Test Reports	Schedule of Items	Requested Samples	Maintenance Manual	WTA Review Period (Weeks)	Contractor Estimated Submittal Date*	Furnish as Submitted	Furnish as Noted	Revise and Resubmit	Rejected	Other
264000	Transformers and Tests	X	X		X	X		X	2						
264000	Switchgear (Draw Out CBs)	X	X	X				X	2						
264000	Switchboards (Fusible and CB)	X	X	X				X	2						
264000	Switchboards and Accessories	X	X	X					2						
264000	Panelboards	X	X			X			2						
264000	Disconnect Switches	X	X						2						
264000	Fuses to 600 Volts	X							2						
264000	Microprocessor Metering	X		X					2						
264000	Automatic Transfer Switches and Tests	X	X	X	X			X	2						
264000	Ground Fault Protection System Tests	X			X				2						
264000	Ground Electrode Test Report	X	X	X	X			X	2						
264500	Grounding and Bonding and Tests	X	X		X			X	2						
265100	Lighting Fixtures Indoors	X				X			2						
265200	Lighting Fixtures Outdoors	X				X			2						
265700	Lighting Control Systems	X		X			X	X	3						
266000	Lightning Protection System	X	X						2						
266500	Engine/Generator and Tests (Below 60	X	X	X	X			X	2						
266500	Protective Housing	X	X						2						
266500	Day or Skid Tank	X	X	X				X	2						
266500	Standby Power RAA	X		X				X	2						

ELECTRICAL SUBMITTAL SUMMARY															
Spec. Section No.	Description of Submittal	Catalog Cuts	Plan, Elevations and Details	Wiring Diagrams	Bound Test Reports	Schedule of Items	Requested Samples	Maintenance Manual	WTA Review Period (Weeks)	Contractor		Furnish as Noted	Revise and Resubmit	Rejected	Other
										Estimated Submittal Date*	Furnish as Submitted				
267100	Fire Alarm System and Tests	X	X	X	X	X		X	4						

END OF SECTION 260100

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 260500 – BASIC ELECTRICAL MATERIALS AND METHODS

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.7	GROUNDING AND BONDING SYSTEMS	1
PART 2 - PRODUCTS		2
2.1	SLEEVES AND OPENINGS	2
2.2	FIRESTOP SYSTEMS	2
2.3	ACCESS PANELS	3
2.4	ROOF OPENINGS	3
PART 3 - EXECUTION		4
3.1	SLEEVES AND OPENINGS INSTALLATION	4
3.2	FIRESTOP INSTALLATION	5
3.3	ACCESS PANELS INSTALLATION	6
3.4	ROOF OPENINGS INSTALLATION	6
3.5	CONCRETE WORK	6
3.6	EXCAVATION AND BACKFILL	7

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SECTION 260500 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover basic electrical materials and methods and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.
- E. Provide manufacturer's Seismic Certificate of Compliance for compliance with seismic requirements of International Building Code, Section 262400, and as required by Authorities Having Jurisdiction.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install basic electrical materials and methods as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Basic electrical materials and methods shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Shop drawing submittals shall include but not be limited to the following:
 - 1. Firestop material

1.7 GROUNDING AND BONDING SYSTEMS

- A. Grounding and bonding of electrical system and equipment shall be provided in accordance with Section 264500.

PART 2 - PRODUCTS

2.1 SLEEVES AND OPENINGS

- A. General: Openings or holes in partitions, walls or floors shall be no larger than that necessary to allow passage of the electrical item and proper sealing of annular space. Provide sleeves and openings in partitions, walls and floors for electrical items. Sleeves and openings through fire or smoke partitions, walls or floors shall be sealed using a UL listed fire stop system. Reference FIRESTOP SYSTEMS article for manufacturers and details. Provide openings for cable, wire, raceway and similar items not otherwise provided for on Structural Drawings. Holes through all exterior walls above or below grade, and through floors or roofs shall be sealed watertight. For openings in roofs reference ROOF OPENINGS article in this section.
- B. Manufacturer of Watertight Conduit Seals for Walls and Floors:
 - 1. Preset Sleeves: Seals shall be one of the following:
 - a. Concrete wall or floor O-Z Gedney Type "FSK" or "WSK" Series.
 - b. Concrete for wall or floor with membranes use O-Z Gedney Type "FSKA" Series.
 - 2. Afterset Sleeves: Sleeves shall be as appropriate one of the following:
 - a. Concrete Wall or Floor (Core Drilled Holes):
 - 1) O-Z Gedney "CSM" Series.
 - 2) Interlocking Link Type Seals: Provide interlocking link type seals of appropriate size and type for sealing annular space between conduit and wall or between pipe and Arlington appropriate "CPS" Series sleeve in exterior walls. Links shall be synthetic rubber; pressure plates, bolts, nuts and washers shall be stainless steel. Seals shall be suitable for watertight installation and shall withstand a hydrostatic pressure of 20 psi. Contractor shall have the option to use matching up Schedule 40 steel sleeve as provided by seal manufacturer.
 - a) Crouse-Hinds appropriate "Link-Seals."
 - b) Calpico Inc. appropriate "Pipe Linx."
 - b. Drywall Partition or Wall: Provide steel sleeve through wall or partition with washers and couplings and seal with appropriate fire stop material to maintain its smoke or fire rating.
 - 1) Afterset Sleeves: Sleeves shall be Unique Fire Stop Products (251)960-5018. Use UL listed systems SP, TP or SSS Series as required in 1 inch, 2 inch or 4 inch (I.D.) sizes.

2.2 FIRESTOP SYSTEMS

- A. General: Firestop systems shall be UL listed or Factory Mutual approved. Contractor shall select and install the proper firestop system with classified products and materials compatible with the type penetrating electrical elements, type of construction material and dimensions of the wall, partition, barrier, or floor and the environment and temperature range of both sides of the opening. Through penetration firestop systems shall maintain the original fire resistance rating of the wall, partition, barrier, or floor prior to the penetration. Expansion type firestop material shall be used where necessary to protect and close the opening upon failure of the penetrating electrical element due to fire.
- B. Approved Manufacturers:
 - 1. Johns Manville International Inc. - Firetemp Systems
 - 2. CSD Sealing Systems
 - 3. Specified Technologies Inc. (STI)
 - 4. 3M brand
 - 5. Heavy Duty/Nelson

6. International Protective Coating Corporation
7. HILTI, Ciba-Geigy
8. Unique Fire Stop Products

2.3 ACCESS PANELS

- A. General: Provide where required for access to control devices or equipment, junction boxes and pull boxes. See PART 3, INSTALLATION OF ACCESS PANELS article for additional details.
- B. Construction:
 1. For Acoustical Tile Ceilings with Flangeless Construction: 16 gauge steel frame, 18 gauge recessed door panel for receiving acoustic tile as specified under Division 09 work, continuous hinge, flush screwdriver-operated cam lock, white prime coat finish, Milcor Style AT. Access panels will not be required in accessible type ceilings.
 2. For Masonry, Tile or Wallboard Surfaces: 16 gauge steel frame, 16 gauge steel, 1 inch wide flange, 16 gauge steel panels, concealed hinges, screwdriver-operated cam lock, baked enamel prime coat. Final painting to match interior decor as specified under Division 09. Panel shall be Milcor Style M. Access doors in tile walls shall be Milcor Type M, stainless steel.
 3. For Plastered Ceilings or Walls: Concealed flange, recessed door panel to receive plaster under general contract work, 16 gauge galvanized steel frame, 18 gauge galvanized steel panel, 3.4 gauge galvanized steel lathe, continuous hinges, flush latch, white prime coat finish. Final painting to match interior decor as specified under Division 09. Provide Milcor Type AP panel.
 4. For Fire Rated Partition: Access doors in 2 hour fire rated partitions shall be 1-1/2 hour B rated and shall bear the UL label. Doors shall be fabricated of steel and be provided with baked enamel prime coat over phosphate coating; final finish as specified under Division 09. Doors shall be by Milcor.
 5. For Fire Rated Ceiling: Doors for installation in fire rated ceilings shall be UL rated for 1-1/2 hours in walls and for 3 hours in ceilings by Warmock Hersey. Panel shall contain 2 inch of insulation in sandwich type construction and shall have continuous piano hinge. Doors shall have automatic closure with self-latching lock with operating ring. Frames shall have anchor straps and mounting holes. Units shall be prime coated. Doors shall be Karp Model KRP-150 FR.
- C. Other Manufacturers: Similar panels by manufacturers other than that listed, such as the BILCO Co. or Karp Associates will be acceptable.

2.4 ROOF OPENINGS

- A. General: Provide and locate roof openings for electrical raceways for providing electrical service to rooftop mechanical equipment and lightning protection cables,.
- B. Flashing Boots: Flashing base shall be aluminum, PVC or EPDM as appropriate. Flashing caps for base or flashing boots shall consist of EPDM compression molded rubber and stainless steel clamps.
- C. Manufacturer of Flashing Boots: Openings for conduit passing through roof shall be made watertight by means of flashing boots manufactured by Roof Products and Systems Corp., The Pate Co. or Portals Plus Inc.

PART 3 - EXECUTION

3.1 SLEEVES AND OPENINGS INSTALLATION

A. General:

1. Building Structural Members: Sleeves are not permitted through concrete structural members unless indicated on the Structural Drawings or approved by the Architect/Engineer.
2. Openings or holes shall not be larger than that required to install the sleeve or electrical item and firestop system or watertight seal.
3. Electrical and Communication Closet Floor Sleeves: Sleeves shall be provided for all floor penetrations in electrical or communication closets or rooms. Sleeves shall be set watertight and extend a minimum of 1 inch above the floor to help prevent entry of water into the sleeve.

B. Sleeves:

1. Sleeve shall be provided in openings required for passing conduit 2 inch and larger, through smoke or fire partitions, walls or floors. Sleeves shall be provided for all conduits penetrating smoke or fire partitions, where conduit crosses a building expansion joint located within 6 ft. of the penetration. Reference Architect's drawings for location of smoke partitions and fire walls. Sleeves shall allow the electrical item to expand and when necessary, be easily replaced or repaired without increasing the size of the opening. Since materials and systems vary by manufacturer details shown on the drawings are for illustrative purposes only. Contractor shall provide firestop system meeting preceding FIRESTOP SYSTEMS article.
2. Sleeves shall be Schedule 40 black steel extended 6 inches beyond face of partition or floor surface, with threads and caps at each end.
3. Sleeves shall be solidly set in opening. Sleeves shall be appropriate size for passage of electrical item. Annular space shall be sealed in accordance with latest NEC using UL listed material.
4. Watertight Seal of Sleeves below Grade: Steel sleeves with seal of appropriate size shall be used to prevent entry of fluids through concrete walls or floors below grade.
5. Afterset Sleeves: Contractor shall provide openings for sleeves through existing walls or floors. Opening shall not be larger than that required for installation of the sleeve. Surfaces in area of penetration shall be cleaned of loose particles and dust. No moisture or oil on surfaces shall be present. Wall sleeves shall extend 6 inch beyond both sides of opening and floor sleeves shall extend a minimum of 2 inch above the floor to provide a water stop.
6. Preset Sleeves: Contractors shall provide sleeves set in new concrete walls or floors and masonry walls. Sleeves for wall shall match wall thickness. Sleeves for floors shall extend one inch above the floor to provide a water stop. Sleeves in concrete shall be secured to concrete forms.
7. Burrs and sharp edges of sleeves shall be filed smooth.
8. Sleeves provided for future electrical items and those sleeves installed but not used shall be completely sealed with appropriate firestop material.

C. Sleeves in Exterior and Foundation Walls:

1. Electrical items penetrating exterior walls shall pass through Schedule 40 galvanized, PVC coated steel sleeves or other sleeves with appropriate coating to prevent rusting.
2. Reference INSTALLATION OF CONDUIT AND TUBING article in Section 261300 for requirements of sleeves for conduit used in outdoor underground work and outdoor above ground work.
3. All items run through sleeves in exterior and foundation walls shall be sealed watertight.

D. Sleeves in Indoor Walls and Partitions:

1. Raceways and Cable Penetrations:

- a. Masonry or Concrete: Electrical items penetrating masonry or concrete walls shall pass through Schedule 40 black steel pipe sleeves.
- b. Drywall or Gypsum Board: Electrical items passing through new drywall or gypsum board partitions shall pass through Schedule 40 black steel pipe or 20 gauge galvanized sheet steel sleeves.

2. Busway or Cable Tray Penetrations:

- a. Masonry or Concrete: Busway or cable tray penetrating masonry or concrete walls and partitions shall pass through sleeves and angle iron or galvanized sheet steel frames on both sides of wall. Opening between busway or cable tray and wall opening shall be filled with appropriate firestop material. Angle iron frames shall be painted.
- b. Drywall or Gypsum Board: Busway or cable tray penetrating drywall or gypsum board walls and partitions shall pass through sleeves and galvanized sheet steel frames on both sides of wall. Opening between busway or cable tray and wall opening shall be filled with appropriate firestop material.

E. Floors:

- 1. Conduit over one inch shall be installed in sleeves. See INSTALLATION OF CONDUIT AND TUBING article in Section 261300 for additional requirements. All cables run through floors shall be run through sleeved openings.
- 2. Cable or conduit run through floors in unfinished spaces where water could drain to floor below shall be provided with Schedule 40 pipe sleeves extending a minimum of 1 inch above floor to serve as a water stop. Sleeves in finished areas shall terminate flush with floor and shall be Schedule 40 pipe or 20 gauge galvanized steel sheet metal at Contractor's option. Fill space between the cable or conduit and the sleeve with approved firestop materials.
- 3. Floor Slots: Electrical conduits, passing through slots in concrete floor slab shall pass through watertight 1 inch high angle iron frames. Frames shall be fastened to the floor and be sealed with silicone caulking to form a watertight seal. Fill the space between the electrical items and the angle iron frame with the appropriate firestop material.
- 4. Conduits run through sleeves in floor to building exterior below grade shall be sealed watertight.

F. Roofs: Reference ROOF OPENINGS article in this section for details.

3.2 FIRESTOP INSTALLATION

- A. Firestop System Installation: Annular spaces between cable, wire, conduit, and sleeve or hole shall be properly sealed with an approved firestop material. Firestop material may be putty, foam, caulking mortar, wrap or tape as appropriate. Firestop material shall be installed in accordance with manufacturer's instructions. An approved firestop method shall be provided by the Contractor to maintain the original fire rating of the wall, partition, barrier or floor. The firestop system material shall be manufactured by one of those listed in PART 2 of this section of specifications.
- B. Verify and coordinate work with other items by other contractors in the same area that penetrate the fire rated wall, partition, barrier or floor have been installed prior to installation of the firestop system.
- C. Where the firestop system is located at a penetration that would be concealed. The Contractor shall have the Authority Having Jurisdiction; verify its installation prior to its concealment (i.e. penetrations through fire rated walls above drywall ceilings).
- D. Contractor shall correct all unacceptable firestop systems found at no additional cost.

3.3 ACCESS PANELS INSTALLATION

A. Accessibility:

1. Control devices and removable panels on equipment shall be located to provide easy access for inspection and maintenance including removal of interior components.
2. Work installed without regard to accessibility of control devices shall be relocated, offset or rerouted without cost to Owner.

B. Access Panels:

1. Furnish access panels for installation under General Contract work where devices are concealed in walls or above non-removable ceilings.
2. Panels shall be at least 4 inch larger in all dimensions than devices to be accessed and be not less than 8 inch square for wall panels and not less than 12 inch square for ceiling panels. Larger panels shall be provided where opening is to allow personnel entry. No panel for personnel entry shall be smaller than 24 inch x 24 inch.
3. See PART 2, ACCESS PANELS Article for access panel construction.

3.4 ROOF OPENINGS INSTALLATION

A. Roof Openings:

1. Roof openings for conduit shall be sleeved prior to finishing roof.
2. Contractor shall provide flashing boots of appropriate size and type to match the roof construction and item run through the flashing boot.

- #### **B. Flashing boots or base with cap shall be prefabricated type in accordance with details and dimension provided by the Contractor furnishing the conduit or cable.**

3.5 CONCRETE WORK

- #### **A. Housekeeping Pads for Equipment:** Unless otherwise noted, housekeeping pads for electrical equipment shall be provided by Contractor. In general, housekeeping pads shall be 4 inch high unless otherwise indicated. Pads shall have welded wire fabric (6 x 6 - W1.4 x W1.4) or No. 3 reinforcing bars 12 inch o.c. each direction 2 inch above bottom of pad. For concrete pads 6 inch and thicker where indicated, welded wire fabric (6 x 6 - W1.4 x W1.4) or No. 3 reinforcing bars 12 inch o.c. each direction shall be installed both top and bottom, 2 inch below top of pad, and 2 inch above bottom of pad. Top edges of concrete pad shall have 3/4 inch chamfer and pad shall be level within 1/4 inch.

1. Location, size and configuration of housekeeping pads as shown are approximate and will vary with final equipment selection. Contractor shall be responsible for coordinating pad sizes and location with size of equipment installed, and equipment anchoring holes and seismic anchors. Concrete shall extend a minimum edge distance of 4 inch or ten (10) anchor bolt diameters whichever is larger clear of all sides of the equipment.
2. Contractor requiring pad shall provide appropriate anchors and anchor bolts. Where seismic anchoring is required, anchoring shall be in accordance with subparagraph 4. below.
3. Concrete shall be small aggregate, 4000 psi compressing strength in 28 days in accordance with ACI 318.
4. Seismic Anchors for Equipment on Pads: Installation of equipment on pads shall be able to resist seismic forces, see Section 262400 - VIBRATION AND SEISMIC CONTROL for embedment requirements of seismic anchor bolts. Seismic anchor bolts shall extend to proper depth through the concrete housekeeping pad into buildings structural floor slab where applicable.

B. Foundations for Heavy Equipment:

1. Where indicated, equipment such as unit substations or large transformers shall be installed on structural concrete foundations as determined on structural plans. Contractor shall furnish dimensions of equipment to the General Contractor.

2. Contractor shall furnish and install anchors, anchor bolts and vibration isolators.

C. Concrete Encasement (Duct Bank):

1. Where shown or called for in specifications, concrete encasement in trenches for underground conduit shall be provided.
2. Concrete encasement for electrical conduit (duct bank) shall be red colored. See Section 261300, "Sleeves in Exterior and Foundation Walls" paragraph in PART 3 for additional details.

- D. Concrete Pole Bases: Where shown on the drawings or called for in specifications, concrete pole bases shall be provided by the Contractor. Refer to Section 265200, CONCRETE BASES FOR LIGHTING POLES article for additional information.

3.6 EXCAVATION AND BACKFILL

- A. Excavation and backfill required for installation of work under this contract shall be complete responsibility of Contractor. No excavation or backfill shall be done within drip line of trees not shown to be removed. No trees shall be removed without prior approval of Architect/Engineer and Owner. Provide protection for trees within 15 ft. of excavation.

B. Rock:

1. Rock Excavation: See Division 01 of specifications. If rock is encountered, excavate to a point 3 inch below depth required for cable, conduit or duct bank.

- C. Trenching: Trench width shall be no more than required for shoring, bracing and performance of work (approximately 6 inch wider than item buried). Necessary shoring and bracing shall be installed to ensure worker safety and proper installation of electrical work. Depth shall not exceed that required to achieve specified depth of cover and over-dig will be permitted for bedding material only. Trenches shall be open and cut from surface.

1. Direct buried conduit and concrete duct banks shall have trenching as specified in Section 261300, INSTALLATION OF CONDUIT AND TUBING article.

- D. Bedding: Work shall be properly bedded on virgin soil, stone free earth or on granular bedding of sand.

1. Direct buried conduit shall have bedding as specified in Section 261300, INSTALLATION OF CONDUIT AND TUBING article.

E. Backfill:

1. General:

- a. Contractor shall begin backfill of conduit and duct banks after completion of the following:

- 1) Installation has been inspected and approved by Authority Having Jurisdiction.
- 2) All forms, shoring, bracing and debris have been removed.
- 3) Locations of underground services have been recorded for later inclusion on "RECORD DRAWINGS". Reference Section 260100 for details.

- b. Do not place initial or final backfill until trench has been cleared of water and debris.

- c. Backfill Placement:

- 1) Direct Buried Cable or Conduit: Place earth materials in 12 inch lifts compacted to approximate density of surrounding firm soil.
- 2) Duct Banks: Place granular material in lifts of 12 inch maximum compacted thickness densified to a minimum relative density of 95 percent under structures or paved areas and of 90 percent under unpaved areas as determined by ASTM D-1557 (1978).

- d. Conduit and Duct Banks Within Building: Conduits shall be placed in concrete with a minimum of 3 inch concrete encasement.
- 2. Initial Backfill: After replacement of any required bedding material and installing cable or conduit, Contractor shall provide initial backfill in two (2) steps.
 - a. Step One: Initial backfill of clean river sand shall be installed to a minimum of 6 inch above buried conduit or duct bank.
 - b. Step Two: Clay soil or selected job excavated material, provided it is free of vegetable matter, foreign material, or rocks larger than 2 inch, shall be used to continue backfill to within 18 inch of grade before finishing with final backfill materials.
- 3. Final Backfill:
 - a. Backfill Placement for Direct Buried Cable:
 - 1) Cable Installed in Trenches: Place earth materials in 12 inch lifts compacted to approximate density of surrounding firm soil.
 - 2) Direct Buried Cable Installed Under Paved Areas: After installation of short run of PVC in drilled horizontal holes, install cable and provide compaction of loose backfill material similar to existing material at any cave-ins.
 - 3) Buried Cable Outside Building Under Plants or Horticulture Areas: Provide clay soil or site soil free of vegetable matter, foreign material and rocks larger than 2 inch to a point 6 inch below finished grade. From 6 inch below grade to finished grade use virgin soil or clean topsoil.
 - b. Backfill Placement for Buried Conduit:
 - 1) Conduit Installed in Trenches: Place earth materials in 12 inch lifts compacted to approximate density of surrounding firm soil.
 - 2) Conduit Within Building: Conduits shall be in concrete floor slab with minimum 3 inch concrete encasement. Backfill is not required.
 - 3) Conduit Outside Building Under Paved Areas: Provide granular material, 2 inch minus crusher run limestone with copious quantity of limestone dust to bottom of new pavement.
 - 4) Conduit Outside Building Installed in Trenches Under Plants or Horticulture Areas: Provide clay soil or site soil free of vegetable matter, foreign material and rocks larger than 2 inch to a point 6 inch below finished grade. From 6 inch below grade to finished grade use virgin soil or clean topsoil.
 - 5) Conduit Installed Using Trenchless Raceway Under Paved Areas: After installation of trenchless raceway in bored horizontal holes below walks and driveways, provide compaction of backfill loose material at any cave-ins similar to surrounding undisturbed material.
 - c. Backfill Placement for Buried Duct Banks:
 - 1) Duct Bank Installed in Trenches: Place granular in accordance with preceding subparagraph 1. Place earth material in 6 inch lifts compacted to a minimum dry density of 90 percent of maximum dry density as determined by AASHTO-80.
 - 2) Duct Bank Within Building: Conduits shall be in concrete with minimum 3 inch concrete encasement. Backfill is not required.
 - 3) Duct Banks Outside Building Under Paved Areas: Provide granular material, 2 inch minus crusher run limestone with copious quantity of limestone dust to bottom of pavement.
 - 4) Duct Banks Outside Building Under Plants or Horticulture Areas: Provide clay soil or site soil free of vegetable matter, foreign material and rocks larger than 2 inch to a point 6 inch below finished grade. From 6 inch below grade to finished grade use virgin soil or clean topsoil.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- d. Warning Tape: Provide appropriate warning tape approximately 12 inch below grade. Reference section 261950 - ELECTRICAL IDENTIFICATION for additional details.
- F. Safety Protection: Provide required barricades, fencing, bracing, piling, signs, lights and pumping, as necessary for protection of workers and general public. Work shall comply with applicable safety codes and local regulations.
- G. Excess Material: Excess earth and other material resulting from excavation shall be removed from site and legally disposed of by Contractor or when suitable for backfill may be piled at location designated and approved by Owner. Debris, rock and trash shall not be allowed to accumulate and shall be removed from site. Streets and roadways to construction site and private property in immediate area shall be kept in clean condition.
- H. Restoration of Existing Conditions:
 - 1. Backfill to height of rough grade when excavation is within area of finished site work.
 - 2. Final surface and adjacent disturbed areas shall be restored to match original condition by sodding, seeding, asphalt paving or concrete as required.
 - 3. Public Property: Restoration of surface conditions shall meet requirements of Authorities Having Jurisdiction when excavation is on public property.

END OF SECTION 260500

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SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. General Commissioning Requirements for Electrical Systems and Equipment
 - 2. Electrical Systems to be Commissioned

- B. Related Requirements:

- 1. Section 019113 "General Commissioning Requirements".
 - 2. For construction checklists, comply with requirements in various Division 26 Sections specifying electrical systems, system components, equipment, and products.

1.3 DEFINITIONS

- A. BoD: Basis-of-Design Document, as defined in Section 019113 "General Commissioning Requirements."
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. Essential Power Systems: A power system that a facility transitions to in the absence of Normal power. This power includes all systems classified as "standby" or "emergency," including "legally required."
- E. Normal Power Systems: A power system that provides primary power to a facility.

1.4 SUBMITTALS

- A. Action Submittals

- 1. Where required in Division 26 specifications; provide the CxA with actions submittals for all commissioned systems identified in this section.

- B. Informational Submittals

- 1. Pre-Functional Checklists, Start-Up Forms, and Test Reports: Where required in Division 26 specifications; provide the CxA material, installation, and performance test checklists for systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section. Note that Pre-Functional Checklists shall be completed prior to any Functional Performance Testing.

C. IOM Manuals

1. The contractor shall provide the CxA with Installation and Operation Manuals of systems, assemblies, subsystems, equipment, and components for all commissioned systems identified in this section

D. Closeout Submittals

1. Where required in Division 26 specifications; provide closeout submittals for all commissioned systems identified in this section.

1.5 QUALITY ASSURANCE

A. Electrical Testing Technician Qualifications: Technicians to perform electrical Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
 - a. Equipment/instrument identification number.
 - b. Planned Cx application or use.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
2. Test equipment and instrumentation shall meet the following criteria:
 - a. Capable of testing and measuring performance within the specified acceptance criteria.
 - b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - c. Be maintained in good repair and operating condition throughout duration of use on Project.
 - d. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

C. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
 - a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
 - 1) Instrument or tool identification number.

- 2) Equipment schedule designation of equipment for which the instrument or tool is required.
 - 3) Manufacturer, make, model, and serial number.
 - 4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
- b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SYSTEMS TO BE COMMISSIONED

- A. Essential Power Systems
 1. Generator
 2. Automatic Transfer Switches
- B. Lighting Controls
 1. Interior Lighting
 2. Exterior Building and Site Lighting
- C. Building Automation System
 1. Lighting Integration
- D. Instrumentation and Controls associated with all of the above.

3.2 GENERAL TESTING REQUIREMENTS

- A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.
- B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.
- E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.
 - 1. Contributors to development of construction checklists shall include, but are not limited to, the following:
 - a. Electrical systems and equipment installers.
 - b. Electrical instrumentation and controls installers.
- G. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- J. Coordinate schedule with, and perform Cx activities at the direction of the CxA.
- K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.
- L. Provide technicians, instrumentation, tools, and equipment to complete and document the following:
 - 1. Performance tests.
 - 2. Demonstration of a sample of performance tests.
 - 3. Cx tests.
 - 4. Cx test demonstrations.

END OF SECTION 260800

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 261100 – MEDIUM VOLTAGE CABLES

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.7	GROUNDING AND BONDING	1
PART 2 - PRODUCTS		2
2.1	CONDUCTORS (ABOVE 600 VOLTS) (EPR)	2
2.2	WIRE CONNECTIONS AND DEVICES (ABOVE 600 VOLTS)	2
PART 3 - EXECUTION		4
3.1	INSTALLATION AND TESTS OF CONDUCTORS (ABOVE 600 VOLTS) (EPR)	4
3.2	INSTALLATION OF WIRE CONNECTIONS AND DEVICES (ABOVE 600 VOLTS)	7

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SECTION 261100 – MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover medium voltage cables and connection devices and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install medium voltage cables and connectors as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Medium voltage cables and connectors shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. Substitutions shall be provided in accordance with Section 260100, SUBSTITUTIONS article and other articles in this section.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Submit shop drawings in accordance with Section 260100, SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS article and the requirements of this section.
- B. Shop drawing submittals shall include but not be limited to the following:
 - 1. Medium voltage cable and tags
 - 2. Medium voltage cable tests
 - 3. Medium voltage cable connectors

1.7 GROUNDING AND BONDING

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with NEC.
- B. Reference Section 264500 - GROUNDING AND BONDING for grounding of medium voltage cable shields and cable connectors.

PART 2 - PRODUCTS

2.1 CONDUCTORS (ABOVE 600 VOLTS) (EPR)

A. General:

1. This article applies to EPR medium voltage power cable for use on systems above 600 volts. Wire and cable shall be manufactured and tested to comply with the latest revised ASTM, ICEA, AEIC, and UL standards.
2. Medium voltage wire or cable shall be installed in raceway system unless otherwise indicated.
3. Shop Drawings: Cables shall be factory tested by manufacturer prior to shipment in accordance with ICEA S-68-516 Section 6. Multiplexed cables shall be tested after multiplexing. Finished cables shall pass the partial discharge test in accordance with AEIC CS-6 and meet UL 1072. Submit to Architect a "Certificate of Compliance" with ICEA specified tests.
4. Pull and junction boxes for medium voltage wire and cable shall comply with NEC.
5. Pulling Lubricant: Pulling lubricant shall not affect the volume resistivity of any semi-conducting jacket or insulation shield present. The volume resistivity of the semi-conducting material shall at no time increase more than 100 percent when tested via the ICEA T-25-425 method, 194 deg. F. exposure, 7 day test, and with readings made at 73 deg. F. daily.

B. Materials and Applications: Reference Section 264500 - GROUNDING AND BONDING for grounding and bonding of electrical installations.

1. Three (3) single 5 kV conductor medium voltage cables. Conductors shall be MV 105 tape shielded copper power cable suitable for a grounded 4,160 volt, 3 phase system.
2. Conductor: Copper, Class B, compact stranded conforming to the requirements of ASTM.
3. Insulation and Jacket:
 - a. All 5 kV cables shall have 0.115 mils thick thermosetting (EPR) Ethylene Propylene Rubber 133 percent insulation with PVC jacket.
 - b. Insulation and jacket shall be triple extruded in one step to control damage and contamination.
4. Cable jackets shall be identified in accordance with AEIC CS6.
5. Shipping and Handling: Cables shall have factory installed pulling socket at each end. Cables shall be shipped on a reel with cable ends sealed and covered with an overall protective cover. Reels shall be tagged with manufacturer name, cable size, voltage, type and length. Cable shall be stored in strict accordance with manufacturer's instructions.
6. Color Coding:
 - a. Phase A: Red
 - b. Phase B: Blue
 - c. Phase C: Yellow

C. Manufacturers:

1. Cables shall be manufactured by The Okonite Co., General Cable Co. (BICC Brand), or Southwire Co.
2. Cable arc and fireproofing tapes shall be manufactured by 3M.

2.2 WIRE CONNECTIONS AND DEVICES (ABOVE 600 VOLTS)

A. General:

1. This article applies to power cable connections and devices for use on systems above 600 volts.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

2. Connectors and devices shall be compatible with the voltage, any grounding requirements, size conductor, type conductor, type insulation level (100 or 133 percent), type shield, and type terminal to which they are to be attached.
3. Connection devices shall be UL listed. Dual-rated AL/CU compression lugs and connectors shall meet UL 486B test for 194 deg. F. Compression lugs and connectors shall be installed using hydraulic tools compatible with lugs or connectors to be installed. Lugs shall have NEMA standard bolt holes to match bolt diameter and quantity for equipment terminations. Compression lugs shall be long barrel type. When terminating space is limited, short barrel type will be acceptable.
4. Complete Part Numbers: Manufacturer's listed series number, type number or kit number is to establish type and standard of quality. Any prefix, suffix, option or accessory, necessary to be added or deleted to provide all of the required components to make the proper connection shall be Contractor's responsibility.
5. Medium voltage terminations and splices shall be made by qualified personnel with minimum of 3 years experience terminating and splicing the type cable, connectors and devices specified.
6. Verify type connections required at existing transformers and switchgear prior to ordering.

B. Material and Application:

1. Medium Voltage Shielded 5 kV Cable Terminations: Cable termination kit shall be rated at 95 kV BIL and be manufactured to meet IEEE No. 48-1996. Cable terminations, both inside and outside of the building, at switchgear and transformer, shall be made with outdoor type kits. Kits shall contain appropriate stems or lugs, cleaners, insulating and conducting material, tapes, ground straps, solder, and other components required for stress relief cone type terminations.
2. Medium Voltage 5 kV Shielded Cable Permanent Type Splice Kits: Cable splices shall be permanent type kits. Cable splices shall be made with kits containing connectors, cleaners, insulating and conducting materials, tapes, ground straps, lugs, solder and all other components for appropriate size and type cables. Components shall match size and type of conductors and cable insulation outside diameter. Contractor shall verify exact working space required for installing kits prior to ordering.
3. Medium Voltage 15 kV Shielded Cable Separable Type Splice Kits: Contractor shall verify available space in manhole prior to ordering.
 - a. Separable insulated modular connectors shall be dead-break, 95 kV-BIL and meet ANSI/IEEE No. 386-1985 for 15 kV systems. This equipment is rated for 15 kV but may be used on 5 kV systems.
 - b. Separable insulated modular connectors shall have 600 amp rms continuous current rating and accommodate copper cable in size range from #2/0 AWG to 750 kcmil.
 - c. All the kits components including insulation, jackets and inserts used in these splices shall be "peroxide cured" to provide stability of components when exposed to moisture.
 - d. Kits shall be capable of making dead-end, 2 way or 3 way tap splices.

C. Manufacturer:

1. Medium Voltage Shielded Cable Terminations 5 kV Kits:
 - a. 5 kV Single-Conductor Series cable to bus from below: 3M (Class 1) Quick Term III 7600S, or equal by Raychem Corp. Thermofit Series HVT, or T&B Elastimold Series CRT.
 - b. 15 kV Single-Conductor with concentric neutral cable to bus from below: 3M (Class 1) Quick Term III Series 7600S.
2. Medium Voltage 15 kV Shielded Cable Load-break 200 Amp Elbow Terminations at Apparatus Bushing:
 - a. Elastimold Series No. 160 for 15 kV, 200 amp separable insulated elbow connectors rated 95 kV BIL with matching bushing insert.

- b. Cooper Power Systems Series No. 500-10 for 15 kV, 200 amp separable insulated elbow connectors rated 95 kV BIL with matching bushing insert.
 - c. 3M Series 5810 for 15 kV, 200 amp separable insulated elbow connectors rated 95 kV BIL with 3M Series 5810 matching busing insert. Sealing and grounding kit shall be included.
 - d. Sealing and grounding kit for Elastimold or Cooper load-break elbows shall be 3M No. 8460 series.
3. Medium Voltage (5 kV) Shielded Cable Permanent Type Splices Kits:
- a. Permanent Type 5 kV Splice Kits: In-line type for two (2) single-conductors with wire or tape shield: 3M "Quick Splice" Series 5550.

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTS OF CONDUCTORS (ABOVE 600 VOLTS) (EPR)

- A. Cable shall be installed in accordance with 2011 NEC Chapter 3 - Wiring Methods and Materials and 2012 NESC Section 34.
- B. Contractor shall closely supervise the installation and install cables in accordance with manufacturer's instructions.
- C. Cable shall be continuous between equipment terminations unless a splice is specifically identified on the drawings.
- D. Cable shall be installed in conduit or duct except in switchgear, transformer, pull box, and junction box enclosures. Conduit or duct interiors shall be cleaned of foreign material by pulling a brush with stiff bristles through each.
- E. When removing stored cable from reel Contractor shall observe bending and training radii given by manufacturer.
- F. When installing cable at low temperatures, insulation and jacket materials lose flexibility. To keep cable supple, keep it in heated area for at least 48 hours prior to installation.
- G. Pulling Line: Stranded steel pulling line shall not be used in duct banks with PVC or non-metallic conduits. Manila hemp ropes should be used on ducts with non-metallic conduits to prevent notching of conduits.
- H. Pulling Tension: Maximum length of cable pull and pulling tension shall not exceed manufacturer's recommendation or following whichever is less. Cable-pulling tension for copper cables shall not exceed 1000 pounds with use of basket grips or 5,000 pounds per square inch of conductor cross section with use of pulling eyes fastened to conductor. Dynamometer shall be used on pulls in order that these values not be exceeded. Cable shall be pulled slowly and steadily, at a pulling rate of 15 ft. to 50 ft. per minute. Pulling operation shall be continuous until completion.
- I. Swivels: Swivel shall be used on all methods of pulling attachments to ensure free rotation.
- J. Lubricants: Cable-pulling lubricants shall be water-based polymer type UL listed and be compatible with cable jacket and duct in which cable is being installed. Lubricants shall be liberally and continuously applied during entire pulling process.
- K. Dry Cable Ends: Cable ends shall be kept clean and dry both during and after being pulled by being taped or otherwise sealed to prevent entrance of dirt, oil, moisture, etc. Cables receiving water damage shall be replaced or have water removed, and cable tests rerun. Contractor shall replace water damaged cables or remove water, and rerun tests all at his expense.
- L. Spoil Removal: Minimum of 18 inch of pulling end of cable (spoil) shall be removed due to possible damage to jacket and insulating materials under or near location used for basket grip or pulling eye. Additional spoil shall be removed if additional cable damage is evident.

- M. Indoor Vertical Supports: Supports for vertical cable runs shall comply with NEC Article and Table 300.19 for raceways and following:
1. Code sized pull boxes in conduit runs shall be installed with provisions for cable support grips or cable support cabinet bushings.
 2. For cable runs in conduit, the cable support grips in pull boxes shall be of size and type recommended by manufacturer and have safety factor between 3 and 5. Cable grips shall be new and unused and be inspected prior to installation. Cable support grips shall be flexible tinned bronze wire mesh type or wedge plug type.
 3. Exposed Cable Connections to Electrical Gear: Exposed cable runs in the interior of switchboards and switchgear shall be adequately supported with rigidly mounted horizontal supports, cable ties on maximum 2 ft. centers.
 4. Spare Wires: Spare wires shall terminate in pull box or junction box and shall be identified with tag indicating equipment or switchgear in which it originated.
- N. Cable Arc and Fireproofing:
1. Where medium voltage feeders in manholes, handholes, splice boxes, or pull boxes, have two (2) or more separate feeder circuits, and where these feeder circuits enter outdoor and/or indoor primary switchgear, all such circuits shall be arc and fireproofed. Cable pulling lubricants shall be removed prior to application of fireproofing. Exception: Where rigid PVC or steel barriers completely separate each feeder circuit in manholes, handholes, pull boxes or cable trays from other feeder circuits.
 2. Where control or communications cables are in close proximity, 16 inch or less, to medium voltage feeder cables and they are not separated by barrier or in separate raceway, cable arc and fireproofing tape shall be applied.
 3. Furnish and install arcproofing tape using the half-lapped system on cable and any splice or tap. After tape is applied, a holding medium, 1/2 inch wide minimum shall be applied at ends. Arcproofing tape shall be 3M Scotch No. 77 fire and arcproofing tape and holding medium shall be 3M Scotch No. 69 glass cloth tape.
- O. Cables in Manholes: Cables run in manholes shall be mounted on support in such a manner as not to interfere with the safe accessibility of person entering the manholes for installation or maintenance purposes.
- P. Cable Identification:
1. Reference Section 261950 for details of cable tags.
 2. New medium voltage cables in every pull box, manhole and termination shall be identified at each end by use of polyethylene tags permanently attached to cable with nylon ties after any arcproofing tape is applied.
 3. Polyethylene tags shall indicate phase, system voltage and brief load description. Example: Slide 1 "4,160 VOLTS"; Slide 2 "PHASE A"; Slide 3 "NORTH CAMPUS"; etc. Verify exact requirements with Owner prior to installation.
- Q. 5 kV Cable Tests:
1. Factory Tests: Contractor shall submit for approval and before shipment of cable, certified factory test data following tests made in accordance with ICEA/NEMA and AEIC for all medium voltage cables.
 - a. Voltage tests (A/C and D/C)
 - b. Insulation resistance
 - c. Corona level
 - d. Cable dimensions
 - e. Insulation thickness
 - f. Conductor insulation
 - g. Cold bend and dielectric test
 - h. Data and location tests performed

2. Cable Insulation Tests:

- a. After "new" cables circuits (not new/existing cable circuits) and all possible cable heads, stress cones, connectors, and associated accessories are installed but before cable is terminated and the new equipment and energized, the following high-potential DC field tests shall be performed by an approved independent testing service employed by Contractor. Contractor shall provide manpower assistance to cable tester for removing jacket and shield 24 inch from ends of cable, insulation 2 inch from testing ends, taping of both ends, and miscellaneous labor required to facilitate testing. New cable, splices and terminations installed under this contract shall be field tested before being energized. Architect and/or Owner's Representative shall be present at tests for observation.
- b. Test methods for new cables subject to approval of independent testing service shall be as follows:
 - 1) For "new" cables apply DC test voltage in 2.5 kV steps for 5 kV shielded cables increasing the value to a maximum of 25 kV for 5 kV (EPR) cables. Allow voltage to establish at each level and record voltage, leakage current and stabilization time.
 - 2) After maximum test voltage is reached, maintain test voltage and record leakage current for first 2 minutes at 30 second intervals and for 13 additional minutes at 1 minute intervals; total time 15 minutes, total readings 17.
 - 3) Good cable, after maximum test voltage is reached, will show a continuous decrease in leakage current with time or stabilization of leakage current without any increase during the test.
 - 4) When leakage current has stabilized and last reading taken, remove applied voltage and allow voltage on cable to decay to zero. Record value of voltage every 30 seconds until zero is maintained.
- c. Certified Test Report:
 - 1) Submit certified test report of recorded data to Architect. Data reduced to graphical form shall be supplemental to recorded data. Certified test reports shall be provided according to Section 260100, TESTING article.
 - 2) Care shall be taken to properly identify the phase conductors tested in test recordings and graph plottings.
 - 3) Record date and time of test, ambient temperature and weather conditions at test location.
- d. Faults During Testing: If during field proof testing a fault in cable, splice or termination becomes apparent, Contractor shall replace faulted cable, splice or termination kit and cable shall be retested.
- e. Repairs: Contractor shall, as part of this contract, absorb costs of replacement of cables, splices and associated terminations necessary to provide a complete and quality installation.
- f. Existing Raceway: Conditions of raceway shall be noted separately. Raceway system shall be observed for water, rust and general appearance.
- g. Independent Testing Service: Approved testing services are:

Mr. Larry Fortier
(847) 608-6788
Fortier Testing & Sales
228 Will Scarlett Ln.
Elgin, IL 60120

Mr. Steve Reed
(314) 890-9999
Electric Power Systems
21 Millpark Ct.
Maryland Heights, MO 63043

Mr. Robert Ross
(816) 525-7156
Electrical Reliability Services
348 NW Capital Dr.
Lee's Summit, MO 64086

3.2 INSTALLATION OF WIRE CONNECTIONS AND DEVICES (ABOVE 600 VOLTS)

- A. Medium Voltage Shielded 5 kV Cable Terminations:
 - 1. Kits shall match size and type of conductor, type of cable insulation, specified voltage, and specified insulation outside diameter.
 - 2. Compression type connector required shall match terminal provisions provided in switchgear, transformer, or circuit breaker.
 - 3. Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating shielded cable.
 - 4. Termination shall match system voltage with the correct quantity of insulator skirts in accordance with manufacturer's requirements. Skirts for cable connections run down to bus from above shall be inverted in position to allow shedding of water or dirt by gravity.
 - 5. Cables with shields shall have shields grounded.
- B. Medium Voltage 15 kV Shielded Cable Load-Break Elbow Terminations at 200 Amp Apparatus Bushing:
 - 1. Make elbow termination installation in strict accordance with manufacturers instructions.
 - 2. Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating shielded cable.
- C. Medium Voltage 15 kV Shielded Cable Dead-Break Elbow Terminations at 600 Amp Apparatus Bushing:
 - 1. Make installation in strict accordance with manufacturer's instructions.
 - 2. Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating shielded cable.
- D. Medium Voltage 5 kV Shielded Cable Permanent Type Splices:
 - 1. Kits shall match size and type of conductor, type of cable insulation, specified voltage, and specified insulation outside diameter.
 - 2. Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating shielded cable.
 - 3. Splices in manholes shall not interfere with accessibility of persons, or space for future access.

END OF SECTION 261100

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 261200 – CONDUCTORS AND CABLES (TO 600 VOLTS)

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.7	GROUNDING AND BONDING SYSTEMS	1
PART 2 - PRODUCTS		2
2.1	CONDUCTORS (TO 600 VOLTS)	2
2.2	WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)	5
PART 3 - EXECUTION		7
3.1	INSTALLATION AND TESTS OF CONDUCTORS (TO 600 VOLTS)	7
3.2	INSTALLATION OF WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)	10

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SECTION 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS)

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover conductors, cables and connectors to 600 volts and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install conductors, cables and connectors as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Conductors, cables and connectors shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Shop drawing submittals shall include but not be limited to the following:
 - 1. Conductors (to 600 volts) tests
 - 2. Connection devices (to 600 volts)

1.7 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with the NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for grounding of non-current carrying metallic parts of electrical equipment using the equipment grounding conductor.

PART 2 - PRODUCTS

2.1 CONDUCTORS (TO 600 VOLTS)

A. General:

1. This article applies to low voltage wire and cable for application to systems of 600 volts or less. Conductors shall be UL listed.
2. Low-voltage conductors used on systems to 600 volts shall be installed in a raceway system unless otherwise indicated. Conductors located in air plenums but not in steel raceways shall have "plenum rated" type insulation.
3. Electrical Connections: Size (AWG) of conductors used shall be based on their temperature rating while not exceeding the temperature rating of both line and load side equipment listed or identified for use with such conductors.

B. Materials and Applications:

1. Conductor Material and Stranding: Conductors shall be insulated copper. Feeder and branch circuit conductors #8 AWG and larger shall be stranded unless otherwise indicated.
2. Building Wire and Cable: Building wire and cable shall have 600 volt insulation with continuous operating temperature rating indicated. Building wire and cable shall be used for following applications:
 - a. Feeders and Branch Circuits (#12 AWG and Larger): For feeders and branch circuits run in raceways unless otherwise noted, use required quantity of conductors in sizes #12 AWG and larger. Insulation of conductors shall be type THWN/THHN, dual rated for 167 deg. F. wet, 194 deg. F. dry, with nylon jacket.
 - b. Service Feeders: For service feeders run in raceways, use required quantity of stranded conductors. Insulation of conductors shall be Type XHHW, dual rated for 167 deg. F. wet, 194 deg. F. dry.
 - c. Low Temperature Feeders and Branch Circuits (#14 AWG and Larger): For feeders, branch circuits and low temperature wiring run in raceways below grade or to cold rooms and cooling towers, use required quantity of conductors in sizes #14 AWG and larger. Insulation of conductors shall be Type USE with RHH/RHW, dual rated 167 deg. F. wet, 194 deg. F. dry (75 deg. C. wet, 90 deg. C. dry) insulation.
 - d. Control Circuits for Lighting and Power (#14 AWG and Larger): For lighting and power control circuits run in raceways to control devices, use stranded, single conductor sizes #14 AWG and larger. Conductor insulation shall be Type THWN/THHN dual rated for 167 deg. F. wet, 194 deg. F. dry (75 deg. C. wet, 90 deg. C. dry), with Nylon jacket.
 - e. Site Lighting Feeder and Branch Circuits (#12 AWG and Larger) in Conduit: For site lighting circuits underground exterior to building in buried conduit provide THWN 167 deg. F. wet for sizes #12 AWG and larger. All conductors shall be stranded for added flexibility. Grounding conductors shall be included in the entire length of all underground site lighting circuits.
 - f. Metal-Clad Cable (Type MC): Metal-clad cable shall be factory assembled multi-conductor cable provided with an equipment grounding conductor. Conductors shall be insulated, be grouped together and be enclosed in a single metallic sheath. Cable shall be manufactured in accordance with UL 1569.
 - 1) Concealed Dry Location Branch, Control and Signal Circuits #12 Through #2 AWG: For concealed indoor dry location standard power receptacle and lighting branch, control and signal circuits use interlocked galvanized steel or aluminum sheathed, multi-conductor, metal-clad cable with copper conductors in sizes #12 through #2 AWG. Insulation of conductors shall be THHN rated for 194 deg. F.

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Webster University
Cannon Design Project No. 004561.01**

3. Fire Pump Feeder with 2 Hour UL Rating:
 - a. Provide Mineral Insulated (MI) 2 hour rated for fire pump feeders not encased in concrete. Cable shall be factory assembled, mineral insulated, sheathed cable with solid copper conductors. Insulation shall be highly compressed magnesium oxide to provide correct spacing of conductors. Cable shall meet NEC.
 - b. Provide 600 volt power cable classified for 2 hour fire rating in EMT conduit. Cable shall be UL listed Type RHH, 194 deg. F. insulation.
4. Low Voltage Control Switching System: For low voltage transformer/relay relay control wiring to wall switches or time switches, use plenum rated multi-conductor or plenum rated multi-pairs in minimum #16 AWG stranded copper with shield when run above ceiling in conduit.
5. Auxiliary Systems: Low voltage wiring for signal, control, or communication systems shall be as follows:
 - a. Remote Control, Signaling and Power Limited Circuits: Wiring for these circuits shall be provided in accordance with NEC.
 - b. Fire Alarm Systems: Wiring for fire alarm systems shall be provided in accordance with NEC. Reference Section 267100 for additional details.
 - c. Paired Cables: Unshielded Twisted Pair (UTP) cables shall be provided in accordance with Division 27.
6. Building Wire Color Coding:
 - a. General:
 - 1) All conductors shall be insulated and color coded unless otherwise indicated.
 - 2) Conductors shall be continuous and of the same color identification from point of origin to point of termination throughout each system. However, conductor jacket or insulation for #4 AWG and larger used on AC power systems need not be color coded their entire length but shall be identified at all termination points including junction and pull boxes by means of 1/2 inch color taping or painted band.
 - 3) Wire or cable with white, gray, green or green with yellow tracer insulation shall not be used for ungrounded AC power branch circuits or feeder conductors.
 - 4) Existing Areas: Contractor shall verify color coding of each existing electrical system and match in order to prevent changing of phase identifications and changes of existing motor phase rotation where they are being refed.
 - 5) Neutrals of Different Systems in Same Enclosure: Neutrals of different systems shall be identified differently. One system neutral may be "white" or "gray" and the other must be "white with a color stripe" (not green) its entire length.
 - b. Branch Circuits: Insulation of branch circuit conductors for each AC power electrical system shall be, unless otherwise indicated, color coded as follows:

120/208 volt, 3 phase, 4 wire
Phase A = black
Phase B = red
Phase C = blue
Neutral = white

277/480 volt, 3 phase, 4 wire
Phase A = brown
Phase B = yellow
Phase C = orange
Neutral = gray

- c. Feeders Circuits: Insulation of AC feeder circuit conductors shall be color coded the same as the branch circuits.
 - d. Equipment Grounding Conductor: Insulation of the equipment grounding conductor run with the AC circuit conductors shall be green or be bare.
 - e. Signal/Yellow Ground Conductor: Insulation of the signal ground conductor shall be yellow/yellow/green.
7. Building Wire Conductor Sizes:
- a. Branch Circuits: Minimum size wire for AC branch circuits shall be #12 AWG, however, lighting and power branch circuits shall be sized for maximum 3.5 percent voltage drop. Branch circuit runs in excess of 75 ft. shall be a minimum #10 AWG. Branch circuit runs in excess of 125 ft. shall be minimum #8 AWG. All 120 volt branch circuit wiring in conduit to a 20 amp single pole circuit breaker shall be sized in accordance with following table.

PERCENT VOLTAGE DROP TABLE FOR THWN 75 DEG. C.									
WIRE NOT EXCEED 'G	50 FT.	75 FT.	100 FT.	125 FT.	150 FT.	175 FT.	200 FT.	250 FT.	300 FT.
#12 AWG	2.1%	3.2%							
#10 AWG	1.4%	2.1%	2.8%	3.5%					
#8 AWG	0.9%	1.3%	1.8%	2.2%	2.7%	3.2%			
#6 AWG	0.6%	0.9%	1.2%	1.5%	1.8%	2.0%	2.4%	2.9%	3.5%
MAXIMUM 14 AMPS, 120 VOLTS AT 0.80 P.F.									

- b. Feeder Circuits: Electrical distribution feeders for electrical systems shall be sized as shown.
 - c. Lighting and Power Control Circuits: Minimum size conductor for lighting and power control wiring shall be #14 AWG. Smaller sizes may be used if fuse overcurrent protection does not exceed the current carrying capacity of the wire.
 - d. Direct Burial Circuits: Direct burial circuits shall be sized as shown.
8. Auxiliary Systems: Wiring for signal, control or communication systems shall be color coded as follows:
- a. Auxiliary System Circuits: Auxiliary system circuits shall be color coded and numbered in accordance with system manufacturer's recommendations or in manner approved by Engineer.
 - b. Fire alarm cables shall be color coded and numbered in accordance with the system's Authorized Distributor's wiring diagrams. The overall jacket of communication system cables shall be color coded as follows:

Fire Alarm	=	red
PA/Intercom	=	gray
Security	=	brown
Telephone (Voice)	=	white
HVAC Control	=	green
Data	=	blue
9. Low Voltage Control Switching System Cables Above Suspended Ceilings: Low voltage control switching system cables to be installed above suspended ceilings shall be provided with J-hooks for a small bundle of cables. J-hooks shall be fastened to an independently hung drop wire. J-hook supports shall provide 0.45 lb/ft. loading and meet 1997 TIA 569-A.
10. Auxiliary System Cable Supports Above Suspended Ceilings: Auxiliary system low voltage cables to be installed above suspended ceilings shall be provided with J-hooks for a small bundle of cables. J-hooks shall be fastened to an independently hung drop wire.

C. Manufacturers:

1. Building Wire: Building wire manufacturers shall be Aetna Insulated Wire, Encore Wire Corp., or Southwire.
2. Low Voltage Switch Wiring: For low voltage control switching system for lighting use multi-pairs of #16 AWG stranded copper manufactured by Beldon or Manhattan.
3. Auxiliary System Wiring: Auxiliary system wire manufacturers shall be Beldon, Berk-Tek, Alpha, Anixter, or West Penn.
4. Metal-Clad (MC) Cable, Box Fittings and Support Clips:
 - a. MC Cable:
 - 1) Dry location interlocked steel or aluminum sheathed metal-clad cable with copper insulated 194 deg. F., THHN phase, neutral and grounding conductors and associated box fittings manufacturer shall be ALFLEX (Armorlite), Coleman Cable Co., or AFC/a Monogram Co.
 - 2) Squared aluminum sheathed metal-clad cable with copper insulated 194 deg. F., THHN phase, neutral and grounding conductors and associated box fittings manufacturer shall be Coleman Cable Co.
 - b. MC Cable Fittings:
 - 1) Fittings for interlocked aluminum sheathed metal-clad cable shall be Killark (Clencher), O-Z Gedney Co. (Fast-Fit), Thomas & Betts (Spin-On), or O-Z Gedney Co. (Speed-Lock).
 - 2) Fittings for interlocked aluminum sheathed metal-clad cable with PVC jacket shall be Killark, O-Z Gedney Co., PLM, or Thomas & Betts.
5. Supports for Cables (Not-in-Raceway or Cable Tray) Above Accessible Ceilings: Wire or cables supported above accessible ceilings not in conduit or cable trays shall be supported above the ceiling on independently hung support wires on ring, hook or loop type hangers manufactured by ERICO Products Inc., Arlington Industries Inc., CPI (Chatsworth Prod. Inc.), or B-Line. Grommet material for protection of cables shall be Arlington Industries Inc. (The Centipede), or other appropriate material.
6. Fire Pump Feeder:
 - a. MI fire pump feeder power cable UL listed for 2 hour fire rating shall be BICC Pyrotenax (System 1850).
 - b. RHH, 2 hour rated cable shall be Draka Cableteq "Lifeline".

2.2 WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)

A. General:

1. This article applies to all wire and cable connections and devices used on systems of 600 volts or less.
2. Connection devices shall be UL listed to match the required wire or cable size combination. Compression and mechanical lugs and connectors shall be dual-rated AL/CU to meet UL 486B test for 194 deg. F.
3. Compression lugs and connectors shall be installed using hydraulic tools compatible with lugs or connectors to be installed. Lugs shall have NEMA standard bolt holes to match bolt diameter and quantity for equipment or motor terminations.
4. Connectors and devices shall be compatible with voltage, grounding requirements, size conductor, type conductor, type shield, and type terminal to which they are to be attached.
5. Complete Part Numbers: Manufacturer's series number, type number and kit number, are to establish type and standard of quality. Contractor shall add or delete as necessary proper prefix, suffix, options and accessories to provide required components to make proper connection.
6. Feeders shall always be continuous or free of both tap splices and straight splices, from the protection device to the equipment unless otherwise indicated.

B. Materials and Applications:

1. Feeder or Large Branch Circuit Straight Splices:
 - a. Straight splices for feeder in sizes #6 AWG through 1500 kcmil shall be made in junction boxes or other appropriate enclosures. Splices shall have compression connectors and cold shrink insulators.
 - b. Tap splices for insulated copper feeders in cable runs from #1/0 AWG through 500 kcmil having a tap from #1/0 AWG through 500 kcmil shall be made in junction boxes or other appropriate enclosures. Splice device shall be UL486B listed and rated at 194 deg. F. Device shall have molded glass filled nylon cover over tin-plated contact teeth that bite cable run and tap conductors by correct torquing of zinc-plated bolts.
2. Motor Lead Splices: Motors having branch circuit conductors #4 AWG and larger shall be connected in motor terminal box with specified motor lead splice kit. Kits shall contain lugs, cleaners, insulating cover, tape and other components required for splicing. Motor splice kit components shall be rated for minimum 167 deg. F. Motor leads and branch circuit wiring shall be copper. Motors with #6 AWG and smaller branch circuit conductors may be terminated with branch circuit splice connectors.
3. Panelboard Gutter Taps: Panelboards required to have gutter taps shall be provided with parallel tap connector and insulating cover of appropriate ratings.
4. Switchgear, Switchboard, and Panelboard Bus Connections: Equipment bus connections shall be compression type lugs. Lugs shall match wire or cable size and equipment terminals.
5. Indoor Branch Circuit Taps and Straight Splices (#8 AWG or Smaller):
 - a. Lighting and power branch circuit copper wire taps and straight splices in junction boxes shall be made using appropriate connectors. Connectors shall be reusable, pressure type spring steel connectors with color-coded insulator good for #8 AWG or smaller solid and stranded conductors. Connectors shall be rated for maximum 221 deg. F.
 - b. Duplex Receptacle Connector with 6 Inch Pigtail: Termination of copper branch circuit wiring and the equipment bonding jumpers at 120 volt duplex receptacles may be through use of devices similar to paragraph a. above but they also have a 6 inch pigtail rated 20 amps with a stripped or stud forked end.
6. Outdoor 120 or 277 Volt Branch Circuits: Connectors rated 221 deg. F. for outdoor power and lighting branch circuits shall be pressure, wire, spring steel type. Connectors shall be UL listed waterproof type with retention fingers and waterproof sealant.

C. Manufacturer:

1. Feeder or Large Branch Circuit Straight Splices:
 - a. Straight Splices: Straight type splices in junction boxes used for splicing conductors in sizes #2 AWG through #2/0 AWG; #2/0 AWG to 250 kcmil; 250 kcmil through 700 kcmil and 750 kcmil through 1500 kcmil provide 3M series 8400 kits consisting of compression type connectors and cold shrink insulators.
 - b. Tap Splices: Tap splices in junction boxes used for splicing conductors in sizes from #8 AWG through #1/0 AWG with a #8 AWG to #2 AWG tap; and conductors from #2 AWG through #4/0 AWG with a #6 AWG to #2/0 AWG tap; and for conductors from 250 kcmil through #1 AWG with a #6 AWG to #4/0 AWG tap and for conductors from 350 kcmil to #4/0 AWG with a #10 AWG to #4/0 AWG tap or #4/0 AWG to 350 kcmil tap shall be ILSCO Corp. KUP-L-TAP Series, Blackburn/Holub IPC (Talon) Series, Buchanan (B-Tap) Series or AMP (Enerperf) series.
 - c. Direct burial tap splices and straight splices for wiring to 1000 volts located in or outside of electric handholes for site lighting and parking lot lighting shall be as specified in paragraph following subparagraph 6.

- d. Feeder tap splices or straight splices inside lighting poles at handholes shall be kit form X8900 Series as manufactured by Joy Manufacturing Co. of LaGrange, North Carolina.
- 2. Motor Lead Splice Kits:
 - a. Pigtail Splice: Pigtail type splice kits shall be 3M Series 5301-5304, Thomas & Betts (MSC Series) or Raychem (MCK Series.)
 - b. In-Line Splice: Straight type splice kits shall be 3M Series 5311-5314 or Raychem (MCK Series.)
- 3. Panelboard Gutter Taps: Gutter taps with insulating covers used in panelboards shall be ILSCO Corp. Type GTA/GTC or GTT/GTC, Blackburn/Holub Type GT, Kupler (KUP-L-TAP) 13000 Series or O-Z Gedney Co. Type PMX.
- 4. Feeder Connections with Compression Lugs to Switchgear, Switchboard, Motor Control Center and Panelboard Main Bus: Compression lugs shall be copper lugs by Blackburn/Holub Type CTL or LCN, Buchanan Type Cytolek or ILSCO Corp. Type CRA-L or CRB-L, or dual-rated AL9CU lugs by Thomas & Betts No. 60100 or No. 60200 Series, or Blackburn/Holub Type ATL or ILSCO Type ACL.
- 5. Indoor Branch Circuit Taps and Straight Splices (#8 AWG or Smaller):
 - a. Connectors shall be 3M Scotchlok-2; Ideal Industries WIRE-NUT or WINGNUT; Buchanan Construction Products Inc., Elastimold Division of Amerace Corp. or WAGO Corp. WC or WD (no-twist) series. Connectors for control and lighting fixture wiring may be 3M Scotchlok self-stripping tap connectors 560 Series.
 - b. Duplex Receptacle Connector with 6 Inch Pigtail: Mar-Tek Industries Term-A-Nut with pigtail for termination of branch circuit wiring at duplex receptacles.
- 6. Outdoor Branch Circuit Taps and Straight Splices:
 - a. Site Lighting (480 Volt) Feeder Connector Kits:
 - 1) Pole Base Fusible Connectors: Connector kits for 480 volt site lighting circuits in lighting fixtures or poles shall be Buchanan (825 Break-away) Series or Bussmann (Tron) Series.
 - 2) Direct Burial Splices Kits: Direct burial multi-mold splice-kits rated 1000 volts shall be 3M Series 85-10 through 85-16 or Raychem Corp. CTE Series.
 - 3) Voltage Drop Connector: Splice connectors in site lighting junction boxes shall be ILSCO No. SPA-O splicer/reducers or other appropriate type. Connectors shall be taped and sealed with 3M No. 2114 potting compound (direct burial splice kit).
 - b. Outdoor 120 or 277 Volt Branch Circuit Connectors 221 deg. F.: Connectors for 120 or 277 volt outdoor power and site lighting branch circuits in outdoor boxes, fixtures or poles shall be King Technology "One-step," Ideal Industries "DB-Plus" or Buchanan "B-CAP Twist and Seal" rated for 600 volts.
 - c. Outdoor 120 or 277 Volt Branch Circuit Connectors 221 deg. F.: High Temperature connectors for 120 or 277 volt lighting branch circuits in fixtures, signs and HID wallpacks shall be High-Temperature Ideal (Wire Nut) or Scru-It Inc.

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTS OF CONDUCTORS (TO 600 VOLTS)

A. General:

- 1. Wiring shall be installed in approved raceways unless otherwise indicated.
- 2. Contractor shall follow conductor manufacturer's installation instructions and shall not exceed conductor's recommended maximum pulling tension (tensile strength) or minimum bending radius.

3. Parallel Conductors in Metallic Conduit: Where 3 phase power is required to be run using parallel conductors per phase and they are run in multiple metallic conduits, each conduit shall contain all 3 phases to prevent heating surrounding metal by electromagnetic induction.
 4. Large Cable Bending: Where cables in sizes No. 1/0 to 750 kcmil are required to be bent to make terminations, special cable bending tools with aluminum rollers shall be used to provide a smooth, scuff-free bend.
 5. Pulling Lubricants: Cable pulling lubricants shall be UL listed and be compatible with type jacket on cable being installed. Wire pulling compound must not set up to prevent future removal of conductors from conduit. Pulling lubricants shall not be used on the branch circuit conductors from GFCI or ELCI branch circuit breakers.
 6. When pulling cables with connectors already attached, Contractor shall isolate the mechanical pulling forces from the connector.
 7. Properly prepare cables and/or wires by cutting and stripping of jacket and insulation prior to making terminations. Care shall be taken to avoid ringing of conductor with stripping tool.
 8. When installing cable or wire at low temperatures the insulation and jacket materials lose flexibility. To keep cable flexible it shall be placed in heated area for at least 48 hours prior to installation.
 9. Auxiliary Systems: Auxiliary system wiring shall be installed in strict accordance with manufacturers wiring diagrams. Reference Section 267100 for additional information on fire alarm wiring requirements.
- B. Indoor Wiring for Feeders and Branch Circuits: Indoor power wiring for feeders and branch circuits shall be installed in raceways.
1. Vertical Supports: Supports for vertical cable runs shall comply with 2011 NEC Article 300.19 for raceways and the following:
 - a. Cable Grips and Support Bushings: Code sized pull boxes in conduit runs shall be installed with provisions for cable support grips or cable support bushings.
 - b. Cable in Conduit: For cable runs in conduit, cable support grips in pull boxes shall be of size and type recommended by manufacturer and have a safety factor between 3 and 5. Cable grips shall be new and unused and be inspected prior to installation. Cable support grips shall be flexible tinned bronze wire mesh type or wedge plug type.
 2. Exposed Cable Connections to Electrical Equipment:
 - a. For short cable runs exposed and terminating in cabinets or equipment, cable support cabinet bushings shall be provided and be sized as recommended by bushing manufacturer.
 - b. Exposed cable runs in interior of switchboards and switchgear shall be adequately supported with rigidly mounted horizontal supports and cable ties, on maximum 2 ft. centers.
 3. Spare Wires: Spare wires shall be provided where indicated. Spare wires shall be run to outlet box, pull box or junction box and shall be identified with tag indicating equipment or panel in which it originated. Spare wires shall be of sufficient length for termination.
 4. Grounding Conductor: Branch circuits shall have insulated copper grounding conductors.
 5. Emergency Conductors: Branch circuit and feeders with these conductors shall be installed a separate raceway from other wiring.
 6. MC Cable for Power Receptacles and Lighting Fixtures:
 - a. General: In lieu of flexible metal conduit and wire concealed in stud partitions for power receptacles and non-accessible ceilings for lighting fixtures where not subject to physical damage MC cable may be used. Provide watertight boxes and cable bushings where MC cable is exposed to moisture. Cables shall be supported in accordance with NEC.

- b. MC Cable in Stud Partitions or Walls for Horizontal Wiring of Power Receptacles: In lieu of flexible metal conduit and wire, metal-clad cable can be run horizontally between wall-mounted duplex power outlets. Metal-clad cable run horizontally between receptacles shall be permitted only for interconnecting of receptacles in partitions or walls that are not running perpendicular to each other. This will permit future relocation of partitions or walls with minimal rewiring. A single vertical run of metal-clad cable may also be used in lieu of a single vertical EMT conduit run to feed the power outlets of each wall or partition. When this is used a single junction box shall be located directly above the ceiling and in line with the first power outlet located in the horizontal run of MC cable. All wiring runs between junction boxes above the ceiling shall be run in EMT.
 - c. MC Cable for Horizontal Wiring of Lighting Fixtures: In dry locations with removable ceilings provide 4 ft. to 6 ft. of flexible type MC cable or flexible metal conduit and wire from a junction box above the ceiling to each flush or recessed light fixture to allow ease of relocation of lighting fixture after its initial installation. Vertical runs to wall switches from a junction box above the ceiling may be MC cable. All wiring between the junction boxes above the ceiling shall be EMT.
- 7. MI Cable for Fire Pump Feeders: Cable shall be installed in accordance with NEC. Cable fittings shall be provided by cable manufacturer. Individual conductors shall be grouped together with steel tie-wraps installed in strict accordance with manufacturer's instructions. Cables shall be supported on maximum of 6 ft. centers. Vertical runs shall be straight and be placed on U-type channel framing members. Bends shall be made in strict accordance with manufacturer's instructions. Provide special box plates for feeders 200 amps and larger. All anchors and mounting hardware shall be steel. Aluminum, plastic, wood, lead anchors, or brackets shall not be used.
- C. Indoor Auxiliary System Wiring For Signal Control and Communications Circuits:
 - 1. Signal, control and communication (not voice and data) wire and cable shall be run in conduit unless otherwise noted. For installation details on voice and data cables reference Division 27.
 - 2. Supports for Cables (Not-In-Raceway or Cable Tray) Above Accessible Ceilings: Total cable weight for each hanger and fastener shall not exceed 75 percent of the manufacturer's loading requirements to allow for additional wiring in the future. Cables (other than telecom) above ceilings shall be supported at a minimum spacing of every 2 ft. to 4 ft. on independent support wires or rods with hangers attached to wire drops or rods. Tighter spacing between supports shall be provided where necessary. Support wires or rods shall not be the same ones supporting the suspended ceilings. Independent support wires shall be secured at both ends (building overhead structure and ceiling). Hangers shall be bridle rings or J-hooks or loops. All rings, hooks or loops used for supports of plenum rated cables shall be made of plenum rated material. Installation of cables shall not block removal of ceiling tiles.
 - 3. Identification: Auxiliary system circuit wiring shall be identified by color code and at both ends with self-adhesive numbers and wire tags as designated on equipment manufacturer's installation drawings.
- D. Outdoor Wiring for Feeders and Branch Circuits:
 - 1. Outdoor branch circuits and feeders on building or structure shall be run in rigid steel conduit unless otherwise indicated.
 - 2. Conduit entries into buildings, both above and below grade, shall be sealed watertight and wiring inside conduits shall be sealed watertight.
 - 3. Underground wiring shall be placed in buried PVC raceway in accordance with Section 261300, Outdoor Underground Conduit Work paragraph in PART 3.

E. Feeder Insulation Tests: Following tests shall be performed on new feeders:

1. Insulation resistance of new feeders shall be tested. Conductor shall have its insulation resistance tested after installation is completed and splices, taps and terminations are made.
2. After disconnecting the feeder's power source, insulation resistance test shall be conducted by using a Megger test instrument. Megohm resistance shall be measured by connecting one terminal of the Megger to the conductor and the other terminal to the grounded metallic conduit in which conductor is installed or to a good ground. Readings shall be observed after 1 minute operation of Megger at slip speed. Megger voltage shall be 500 VDC for testing new conductors with insulation rated to 150 volts and old conductors having insulation rated to 600 volts existing or reused feeders to 600 volts and 1000 VDC for testing new conductors 150 volts to 600 volts. Insulation resistance of conductors shall read above the value in following table. Readings will vary with temperature, humidity, quantity of junctions, and conductor lengths.

Insulation Resistance (Megohms) at 60 Deg. F.

<u>Approximate THWN Insulated Wire</u>	<u>Megohms for 100 ft.</u>
No. 2	2100
No. 1/0	2000
No. 2/0	1900
No. 3/0	1700
No. 4/0	1500
250 kcmil	1700
350 kcmil	1400
500 kcmil	1200

3. Certified test reports shall be provided in accordance with Section 260100, TESTING article. Test reports shall identify each feeder conductor tested and have the following heading:

FEEDERS TESTED						
<u>Date and Temperature</u>	<u>/ /</u>	<u>Deg. F.</u>	<u>/ /</u>	<u>Deg. F.</u>	<u>/ /</u>	<u>Deg. F.</u>
Conductors From						
Conductors To						
Conductor Size Per Phase						
Megohms/Phase A						
Megohms/Phase B						
Megohms/Phase C						
Approximate Length +/- 10 ft.						

3.2 INSTALLATION OF WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)

- A. Material Table: Conducting material of wire, termination devices and electrical equipment busses shall match as follows:

<u>Equipment Bus</u>	<u>Lugs Labeled</u>	<u>Terminating Conductor</u>
Copper	AL9CU	Copper
Aluminum	AL9CU	Copper
<u>Splice Wire (A)</u>	<u>Connector</u>	<u>Splice Wire (B)</u>
Copper	AL9CU	Copper
<u>Motor Term. Wire</u>	<u>Connector</u>	<u>Motor Br. Crkt. Wire</u>
Copper	AL9CU	Copper

- B. Indoor Wiring Connectors for Feeders and Branch Circuits: Field installed connectors shall be made in outlet boxes, junction boxes, equipment, or other appropriate enclosure.

1. Indoor Feeder Straight Splices:
 - a. Appropriate size and type of compression fittings and insulation shall be applied on feeder conductors to provide secure and positive electrical connection.
 - b. In-line feeder straight splices shall be installed in strict accordance with manufacturers instructions.
 2. Indoor Motor Lead Splice Kits: Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating. Motors shall be grounded by installing equipment grounding conductor.
 3. Gutter Taps: Panelboard gutter taps shall have 600 volt, insulating covers over mechanical type tap connectors. Tap holes in tap connector shall match cable diameter. Gutter taps shall be installed in panelboard gutters in accordance with manufacturer's instructions.
 4. Indoor Switchgear, Switchboard and Panelboard Equipment Bus Connections shall be mechanical type. Lugs required for terminating 600 volts wire or cables on equipment shall be mechanical type. Mechanical lugs shall be torqued with Allen wrench to value identified on installation instruction sheets. AL/CU dual rated mechanical lugs shall be rated at 194 deg. F.
 5. Indoor Branch Circuit Taps and Splices: Appropriate size and type of connectors shall be manually twisted or pushed onto branch circuit conductors to provide secure and positive electrical connection. Connector's integral insulator shall completely cover bare portion of stripped conductor.
 6. Fixture Wire Nuts: Lighting fixture branch circuit conductor connections in junction and outlet boxes shall be made with UL listed pressure type spring connectors rated at 600 volts maximum or 1,000 volts maximum when enclosed in fixture or sign.
- C. Outdoor Wiring Connectors for Feeders and Branch Circuits: Field installed connectors shall be made in outlet boxes, junction boxes, equipment, or other appropriate enclosure.
1. Outdoor Feeder Straight Splices:
 - a. Appropriate size and type of compression fittings, insulation or kits shall be applied on feeder conductors to provide secure and positive electrical connection.
 - b. In-line feeder taps and splices shall be installed in strict accordance with manufacturer's instructions.
 - c. Handholes: Feeder taps and splices in handholes shall be multi-mold splicing kits, in-line splices or size splices as appropriate.
 - d. Lighting Pole Bases: Feeder taps, splices and kits in lighting pole bases shall be installed in strict accordance with manufacturer's instructions.
 2. Outdoor Motor Lead Splice Kits: Manufacturer of kits shall supply complete illustrated instructions to show proper installation techniques for terminating. Motors shall be grounded by installing equipment grounding conductor.
 3. Outdoor Branch Circuit Splices: Appropriate size and type of connectors shall be manually twisted or pushed onto branch circuit conductors to provide secure and positive electrical connection. Connector's integral insulator shall completely cover bare portion of stripped conductor. Branch circuit wiring connections shall be made in weatherproof junction and outlet boxes.
 4. Direct Burial Splices (1000 Volts): Direct burial in-line feeder splices kits shall only be used where indicated. Kits shall be installed in strict accordance with manufacturer's instructions.

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 261300 – RACEWAYS AND BOXES

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS	1
1.3	STANDARDS	1
1.4	SCOPE OF WORK	1
1.5	DESCRIPTION OF SYSTEMS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		1
2.1	CONDUIT, TUBING AND FITTINGS	1
2.2	SURFACE RACEWAYS	4
2.3	OUTLET AND SWITCH BOXES	5
2.4	PULL AND JUNCTION BOXES	6
PART 3 - EXECUTION		7
3.1	INSTALLATION OF CONDUIT, TUBING AND FITTINGS	7
3.2	SURFACE RACEWAY INSTALLATION	13
3.3	OUTLET AND SWITCH BOX INSTALLATION	13
3.4	PULL AND JUNCTION BOX INSTALLATION	14

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SECTION 261300 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover raceways and boxes, and their installation applicable to Contractor's work.
- B. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- C. Outdoor and Wet Locations: Where the term outdoor is used in this section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- D. Coordination: Conduit, pull and junction boxes giving right-of-way priority to systems such as plumbing, fire protection, piping, and drain lines required to be installed at a specified slope where space is available.

1.3 STANDARDS

- A. All conduits and fittings shall meet UL and ANSI standard, and be labeled as such.
- B. All plastic conduits and fittings shall meet all ASTM standards.

1.4 SCOPE OF WORK

- A. Contractor shall furnish and install raceway and boxes as specified and indicated.

1.5 DESCRIPTION OF SYSTEMS

- A. Raceways and boxes shall be provided as called for in this section of specifications.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Shop drawing submittals shall include but not be limited to the following:
 - 1. Floor boxes
 - 2. Surface raceways

PART 2 - PRODUCTS

2.1 CONDUIT, TUBING AND FITTINGS

- A. General:
 - 1. Conduit and fittings shall be UL listed.
 - 2. No conduit shall be smaller than 3/4 inch; however, 1/2 inch conduit may be used for wiring to wall switches and control devices.
 - 3. Minimum size of conduit shall be 1/2 inch.
 - 4. Conduit sizes shall be as indicated with conduit fill not to exceed 40 percent.

B. Materials and Applications:

1. Rigid Metal Conduit (RMC): RMC conduit shall be hot-dipped galvanized steel or electro galvanized steel. Raceways shall have sharp clean threads. Running threads for this conduit are not permitted.
2. Corrosion Protected Rigid Metal Conduit: This type rigid metal conduit shall be hot-dipped galvanized steel or electro galvanized steel with linearized phenolic coating. Coating shall be 10 mil thick on both inside and outside surfaces up to threads. Coating shall be suitable for temperatures from -60 deg. F. to 275 deg. F. in dry air. Coating shall be abrasion and impact resistant. Standard color shall be ANSI 70 gray.
3. PVC Coated Rigid Steel Conduit: PVC coated rigid steel conduit shall be hot-dipped galvanized or electro galvanized with 40 mil. PVC exterior coating and 2 mil urethane interior coating or silicone coating.
4. EMT Steel Conduit: EMT steel conduit shall be made from mild steel and be electrically welded and galvanized.
5. Schedule 40 Rigid Non-Metallic Conduit: Schedule 40 rigid non-metallic conduit shall be PVC electrical plastic conduit rated for use with 194 deg. F. conductors. Joints shall be leakproof and be installed in strict accordance with manufacturer's recommendations. Standard lengths may have one belled end.
6. Extra Strength PVC Plastic Utilities Duct (DB) for Underground Installation: Direct buried conduit 1 inch and larger shall be rated for use with 194 deg. F. conductors. Joints shall be leakproof and be installed in strict accordance with manufacturer's instructions. Standard lengths may have one belled end.
7. RTRC Reinforced Thermosetting Resin Conduit: Fiberglass reinforced (RTRC) conduit shall be suitable for continuous operation from -40 deg. F. to +110 deg. F. Each conduit length shall have a bell end with an integral friction coupling for sealing to 15 psi. Conduit shall be UL listed for underground use.
8. Flexible Metal Conduit: Flexible metal conduit shall be interlocked armor, galvanized steel and only be used in dry locations.
9. Liquidtight Flexible Metal Conduit: Liquidtight flexible steel conduit with moisture and oilproof gray PVC jacket shall be used for vibration isolation between mechanical equipment and the conduit system. Conduit shall be rated for ambients between -40 deg. F. to +140 deg. F..
10. Utility Service Conduit for Directional Boring: Directional bored conduit shall be manufactured from select high density polyethylene copolymer. The conduit shall be colored red throughout and be sized as shown on drawings. The Contractor shall coordinate reel links with manufacturer.
11. Unions, Couplings and Fittings:
 - a. RMC Steel Conduit Fittings:
 - 1) RMC steel connecting devices shall be galvanized threaded type. Threads shall be full and clean cut to match conduit.
 - 2) Grounding type insulated bushings and locknuts shall be used on RMC steel conduits that enter metallic enclosures. Grounding bushings with insulated throat for RMC steel conduit shall be O-Z/Gedney Type IBC (Lay-In-Lug), Midwest Electric (Lazy-Lug), or Thomas & Betts (Blackjack).
 - 3) Expansion fittings shall be provided on exposed raceway at building expansion joints and where required to compensate for thermal expansion and contraction. Deflection/expansion fittings shall be provided in embedded raceway in building expansion joints.
 - a) Raceway: RMC with internal bonding; Expansion Fitting Manufacturer/Type: O-Z/AX, Spring City/AF, or Cooper Crouse-Hinds/XJG.
 - b) Raceway: RMC with external bonding for outdoors; Expansion Fitting Manufacturer/Type: O-Z/EX, Spring City/EF, or Cooper Crouse-Hinds/XJG/GJ.

- c) Raceway: RMC watertight (NEMA 4) with neoprene sleeve and stainless steel bands for concrete pours; Deflection/Expansion Fitting Manufacturer/Type: O-Z/DX, Spring City/DF, or Cooper Crouse-Hinds/XD.
 - b. PVC Coated Rigid Steel Conduit Fittings: Coating shall be 40 mil PVC on fittings and straps.
 - c. EMT Fittings:
 - 1) EMT steel conduit fittings shall be zinc-plated malleable iron or galvanized steel.
 - 2) Compression type connecting devices shall be used on EMT conduit connections.
 - 3) Insulating bushings shall be provided on EMT conduit stubs above ceiling. Insulated bushings shall be O-Z Type SBT or Arlington EMT Series.
 - 4) Expansion fittings shall be provided at building expansion joints and where required to compensate for thermal expansion and contraction. Expansion fittings shall be O-Z/Gedney Co. Type TX or Cooper Crouse-Hinds Type XJG.
 - d. Rigid Non-Metallic Conduit Fittings: Rigid non-metallic PVC fittings and connecting devices shall be cleaned, dried and glued to conduit in accordance with manufacturer's instructions.
 - 1) Schedule 40:
 - a) Schedule 40 expansion fittings shall be capable of 6 inch expansion and be similar to Carlon No. E945.
 - b) Schedule 40 couplings shall be female socket type of correct size to match conduit similar to Carlon No. E940.
 - c) Schedule 40 end bells shall be used for duct bank entries into manholes.
 - 2) Schedule 40 Trenchless Raceway: Raceway integral mechanical fittings shall be belled and gasketed watertight and have locking straps for cement-free assembly. Raceway shall be UL listed for directional drilling.
 - e. RTRC Conduit Fittings: Complete line of preconstructed connecting devices shall be made available by manufacturer.
 - f. Rigid Aluminum Conduit Fittings: Rigid aluminum fittings shall have full and clean cut threads to match conduit.
 - g. Flexible Metal Conduit Fittings: Flexible metal conduit fittings shall be of proper size and type to match raceway and box.
 - h. Liquidtight Flexible Metal Conduit Fittings: Liquidtight flexible metal fittings shall be of proper size and type to match raceway and box. Fittings shall provide positive seal against moisture and liquids.
- C. Manufacturers:
- 1. RMC and EMT steel conduit shall be products of Wheatland Tube Co., Allied Tube & Conduit Corporation, LTV (Republic Steel), Steelduct Conduit Products, Hylsa Tubular Products, or Picoma Industries Inc.
 - 2. Exterior 40 mil PVC coated rigid steel conduit with 2 mil urethane or silicone interior coating shall be Plasti-Bond RED product of Robroy Industries Electrical Products Division, Perma-Cote Plastics Inc., Picoma Industries Inc., PCD Inc. (Kor-Kap), or Ocal.
 - 3. RMC and EMT steel conduit fittings shall be products of RACO Inc., Midland-Ross (Steel City), Spring City Electrical Manufacturing Co., O-Z/Gedney Co., or Allied Tube and Conduit Corp. EMT die-cast zinc alloy No. 7 fittings shall be manufactured by Bridgeport Fittings Inc. Conduit sealing bushings for watertight seal of wiring in RMC steel conduit shall be O-Z Gedney CSB Series.

4. Non-Metallic PVC Conduit and Fittings:
 - a. Schedule 40 rigid non-metallic (PVC) conduit NEMA TC-2 shall be products of Certainteed Corp., Ipex, Carlon Electrical Products, CPS, Triangle PWC Inc., or Can-Tex Industries.
 - b. Extra strength PVC plastic utilities duct NEMA TC-8 for underground installations shall be Ipex (DB 120) Can-Tex Type Telec-Con TC-B, CPS Type TC-8-DB, or Carlon Electrical Products Type 120DB.
 - c. Conduit fittings shall be by the same manufacturer as the non-metallic conduit.
 - d. Trenchless Raceway: Manufacturer shall provide detailed installation instructions. Schedule 40 rigid non-metallic (PVC) conduit with watertight fittings used for directional drilling shall be Carlon Electrical Products (Bore-Gard).
5. Flexible metal conduit shall be products of American Flexible Conduit Company, Alflec Corp., or Anaconda Metal Hose. Flexible metal conduit fittings shall be by Midland-Ross (Steel City) or Appleton Electric Co.
6. Liquidtight flexible metal conduit shall be a product of Alflec Corp. (Ultratite), American Flexible Conduit Co. (Amer-Tite) Type UL, Electric-Flex Co. (Liquatite) Type L.A., or Anaconda Metal Hose (Sealtite) Type UA. Liquidtight flexible metal conduit fittings with insulated throat shall be by Midland-Ross (Steel City), Appleton Electric Co., Harvey Hubbell Inc., Ideal, O-Z/Gedney Co., or (Crouse-Hinds) Midwest Electric Manufacturing Corp, or Bridgeport Fittings Inc.
7. Rigid non-metallic RTRC conduit and fittings shall be products of FRE Composites Inc. or Champion Fiberglass.
8. Air and noise sealing material shall be PERMAGUM manufactured by Virginia Chemical, Duct Seal by Panduit Corp., or Blackburn/Holub of American Electric.
9. Rigid steel conduit threaded connections shall have T & B KoprShield applied prior to screwing lengths together.

2.2 SURFACE RACEWAYS

A. General:

1. Provide complete surface-mounted raceway systems as shown and as specified. Raceways shall be provided to exact lengths to match job requirements since lengths shown on drawings are illustrative and diagrammatic only and may not be accurate.
2. Provide necessary elbows, end fittings, tees, connectors, wall boxes, couplings, wire clips, closures, power receptacles, wiring, cover plates and labels as required for complete quality installation. Raceways shall be for inclusion of telephone and/or power outlets unless it is clearly noted as serving as raceway only.
3. Raceways shall be by single manufacturer.
4. Raceways shall be installed to meet NEC. Surface metal raceways shall have means to connect equipment grounding conductor.

B. Materials and Applications:

1. Surface raceway shall be aluminum and have pressure-fitted removable front cover. Sections shall be electrically and mechanically coupled together. Fasteners shall be flush with surface of raceway. Holes in cover of aluminum raceway for power receptacles shall be factory die-cut to match receptacle face.
2. Coordination: The Electrical Contractor shall coordinate die-cut openings and adapters for telecommunication devices with the Telecommunication Contractor. The Electrical Contractor shall provide all adapters to accommodate the telecommunications devices specified for use in surface raceways.
3. Finish and Color of Raceways and Devices: Unless otherwise indicated, aluminum raceway shall have clear anodized finish. field-installed wiring devices shall be gray. Factory prewired and/or field-installed wiring devices in aluminum raceways shall be gray.
4. Wall Plates: In PM-30 and PM-40 steel raceways wall plates for field-installed devices shall match finish of raceway. Reference Section 261400, WALL PLATES article.

5. Outlet Spacing: As indicated on drawings.
6. Wiring Devices: All wiring devices shall have ratings as specified in WIRING DEVICES article Section 261400.

C. Manufacturer:

1. Metallic Raceways With and Without Wiring Devices: Metallic raceways shall be manufactured by Wiremold/Legrand, Versa-Duct/PG LifeLink or Hubbell ALU Series.

2.3 OUTLET AND SWITCH BOXES

A. General:

1. Outlet and switch boxes shall be sized to provide ample space for wiring devices and phase, neutral, switch legs and grounding conductors.
2. Provide barriers in power outlet boxes between devices operating at different voltages or on separate systems such as Normal or Emergency.
3. Boxes installed in masonry or surfaces to receive wood panels, wall covering, casework or similar materials not easily cut and patched, shall be inspected by Architect at time of rough-in. Contractor shall make corrections in rough-in as directed by Architect prior to installation of wall surface or finish.
4. Electrical Outlet Boxes in Single Membrane (one side) of a Fire Resistance Rated Wall, Ceiling or Floor:
 - a. Non-combustible or steel box in the wall shall not exceed 16 square inch in area. Boxes on opposite sides of the wall shall be horizontally separated by 24 inch minimum.
 - b. Non-combustible or steel boxes in the fire resistant rated floor/ceiling or roof/ceiling shall not exceed 100 square inch for any 100 square ft. of ceiling area.

B. Indoor Box and Bracket Materials and Applications:

1. Metallic Boxes:
 - a. Indoor flush or surface boxes used with concealed EMT steel conduit shall be square, octagon or rectangular and have knockouts on all sides. Boxes may be single or multi-gang type as required. Outlet boxes shall be made from galvanized steel unless otherwise indicated.
 - b. Wet and Damp Location: Indoor boxes used with rigid steel conduit shall be cast malleable iron type designed for use in wet locations.
2. Flush Wall Box: Flush wall boxes for switch and power receptacle wiring devices shall be steel measuring a minimum 4 inch square x 1-1/2 inch deep except where modified for narrow partitions or hollow installations. Boxes shall be set back to allow the installation of the raised device cover. Depth of the raised portion of the device cover shall match wall construction. Device cover shall match quantity of devices to be installed and allow the device and its wall plate to be flush with the finished wall.
3. Boxes with Multiple Devices: Where two (2) or more switches and/or receptacles are located adjacent to each other, they shall be installed in one box with one common wall plate.
4. Separate Boxes:
 - a. Voice/Data and Power: Where voice/data outlets are indicated alongside power receptacles boxes for voice/data shall be separated from power boxes and have separate wall plates.
 - b. Special Devices: When wiring devices, are shown side-by-side with special wiring devices, such as lighting dimmers or exhaust fan control switches, separate boxes shall be installed for the special devices to provide clearance between special device wall plates.
5. Boxes in Narrow Partitions: Where switch boxes are installed in narrow wall partitions 2-1/2 inch or less, 2 inch wide x 3-3/4 inch high x 1 inch deep steel box shall be used.

6. Boxes in Hollow Metal Supports: Where switch boxes are shown for installation in hollow metal supports, doorjamb or mullions, steel boxes 1-5/16 inch wide x 3-3/4 inch high x 1-5/8 inch deep shall be used.
7. Boxes In Metal Studs: Outlet boxes shall be 4 inch square x 1-1/2 inch deep and be mounted to metal studs and have INSTANT-ON mounting brackets to suit stud size.

C. Outdoor Box Materials and Applications:

1. General:
 - a. Boxes shall be single or multi-gang type with conduit fittings as required.
 - b. Boxes shall be flush unless otherwise indicated.
 - c. Totally exposed boxes shall be UL listed watertight boxes.
2. Metallic Boxes: Recessed-mounted outdoor boxes used in conjunction with rigid steel conduit shall be cast malleable iron type when recessed in masonry walls. Surface-mounted outdoor outlet boxes used in conjunction with rigid steel conduit shall be FS or FD cast device type boxes. Boxes shall have appropriate size and quantity of conduit hubs and be weatherproof, raintight and dusttight with gasketed covers.

D. Manufacturers:

1. Indoor and outdoor metallic flush boxes shall be products of RACO Inc., Appleton Electric Co., Midland Ross Corp. (Steel City), Valen Manufacturing Co., or Thepitt Manufacturing Co. Indoor surface-mounted cast aluminum boxes shall be the product of Pass & Seymour or approved equal.
2. Narrow partition metallic switch boxes shall be RACO Inc. No. 403 or equal. Hollow metal jambs or mullion switch boxes shall be RACO Inc. No. 426.
3. Exposed and recessed metallic outdoor boxes or boxes in indoor wet or damp locations shall be malleable iron type products of Killark Electric Manufacturing Co., O-Z Gedney Co., Appleton Electric Co., or Crouse-Hinds Co.

2.4 PULL AND JUNCTION BOXES

A. General:

1. Pull and junction boxes are not completely shown. Boxes for wiring both to 600 volts and above 600 volts, shall be sized and installed where required in accordance with NEC. Boxes larger than code requirements shall be provided where wire or cable manufacturer requires larger bending radius than required by NEC and where taps or splices would be compressed by placement of the box cover plate. Pull and junction boxes shall have screw on removable cover mounting hardware shall be galvanized steel.
2. Pull and junction boxes shall be galvanized sheet steel and be suitable NEMA type to match environment of the box location. Boxes shall have continuously welded seams.

B. Materials and Applications:

1. Dry Locations:
 - a. Indoor feeder metallic boxes shall be constructed of minimum 14 gauge hot-dipped galvanized steel, cast or sheet aluminum with screwed on or hinged cover with locking latches. Cover plate screws shall be corrosion-resistant machine type.
 - b. Indoor branch circuit metallic boxes used with EMT conduit shall be square, octagon or rectangular constructed of minimum 14 gauge hot-dipped galvanized steel, cast or sheet aluminum, and have knockouts on all sides. Cover plate screws shall be corrosion-resistant machine type.
2. Outdoor and Indoor Wet Locations:
 - a. Feeder metallic boxes shall be UL listed watertight boxes. Boxes shall have gasketed and screw type covers, and have threaded connections that are watertight bolt-on hubs, sealing-locknuts for RMC steel conduit. Cover plate screws shall be corrosion-resistant machine type.

- b. Branch circuit metallic boxes used with RMC steel conduit shall be FS or FD cast type boxes. Boxes shall have threaded fittings and be weatherproof, raintight and dusttight with gasketed covers. Totally exposed boxes shall be UL listed watertight boxes.
- 3. Metallic boxes shall be UL listed watertight boxes. Boxes shall have gasketed screwed on type covers, and have locknuts, for RMC steel conduit connections. Screws and other fasteners shall be nickel plated, or stainless steel to prevent corrosion. Boxes below grade or encased in concrete shall be cast iron or hot-dipped galvanized steel. Boxes above grade shall be cast aluminum. Aluminum boxes shall not be encased in concrete. Cover plate screws shall be corrosion-resistant machine type.
- C. Manufacturers:
 - 1. Indoor metallic junction and pull boxes shall be manufactured by RACO, Queen Products Co., Wadsworth Electric Manufacturing Co., Hoffman Engineering Co., E.M. Wiegmann & Co. Inc., Fab-Con, or Indquip Engineering Inc.
 - 2. Outdoor and wet location metallic junction and pull boxes shall be manufactured by Killark Electric Mfg. Co., Appleton Electric Co., O-Z/Gedney Co., or Crouse-Hinds Co.
 - 3. Conduit sealing bushings shall be O-Z/Gedney Type CSB or Spring City.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT, TUBING AND FITTINGS

- A. General (All Conduit and Tubing):
 - 1. Record Drawings: Location of underground conduits, medium voltage conduits, conduits from switchgear to switchboards and conduits from switchboards to panelboards or automatic transfer switches, conduits between panelboards and other concealed conduits shall be indicated on record drawings. Reference Section 260100, RECORD DRAWINGS article for details.
 - 2. All conduit shall be run parallel with or perpendicular to building structural members, however, obstructions may be cleared by use of bends, offsets, and where necessary, junction and pull boxes. Conduits mounted on walls shall be mounted plumb and in a neat and orderly manner.
 - 3. Cutting and Cleaning: Conduits shall be cut square, reamed and cleaned before installation. Before installing any wire in conduit, Contractor shall remove all water, condensation and obstructions that may have accumulated. PVC coated conduit that is scratched enough to remove the PVC coating shall be touched up in accordance with manufacturer's instructions.
 - 4. Building Expansion Joints: Expansion fittings shall be provided in raceways at building expansion joints and elsewhere when raceways are required to compensate for thermal expansion and contraction. Indoor expansion fittings in steel conduit shall allow minimum of 4 inch movement (2 inch each direction). Deflection fittings shall be provided where required to compensate for linear expansion or contraction up to 3/4 inch and angular misalignment of up to 30 degrees. Fittings shall be installed under strict accordance with manufacturer's instructions.
 - 5. Bends: Field-made bends in runs of conduit shall be made only with equipment intended for the purpose and shall not effectively reduce internal diameter. Bends on conduit runs between two (2) points of conduit termination shall not exceed 360 degrees total for "power wiring" or 180 degrees total for "voice/data" or "communications wiring". A pull box shall be installed between the two (2) points of a conduits termination for additional bending. PVC conduit bends, elbows and other fittings shall be capable of freely passing a ball that is 1/4 inch less in diameter than nominal bore of conduit. Long radius bends shall be provided where required to prevent violation of minimum bending radius of conductors as indicated by conductor manufacturer and allow easier pulling.
 - 6. Conduit Within or Under Concrete Floor Slabs: Conduit installed within or under concrete floor slabs within building not having access from below and located on or below grade

- shall be rigid PVC and be totally encased in a minimum of 2 inch of concrete on all sides to maintain rigidity of raceway system. Last conduit elbow and stub-up shall be PVC coated rigid steel conduit. Conduit stub-up shall have watertight seal around wiring in conduit.
7. Conduit shall not be allowed in floor slabs unless specifically approved by Structural Engineer.
 8. Ends: Ends of conduits shall be capped during rough-in to seal out moisture, plaster and dirt.
 9. Damaged: Crushed or deformed conduits shall not be used.
 10. Clearance and Vibration Isolation: Conduits shall be run at least 6 inch clear of steam and hot water pipes. Only flexible conduits shall come in contact with, or be attached to any electrical devices in piping or ductwork. Other conduits shall be mounted clear of piping and ductwork to avoid vibration transmission.
 11. Empty or Spare Conduit: Indoor empty or spare conduits shall contain pull wires or nylon cord with a minimum of 36 inch extra length looped at ends. In outdoor conduits provide nylon or polyester pull rope or cord rated 240 pound test or equivalent. Empty and spare conduits shall be sealed and capped prior to concrete pour. Caps shall not be removed until conduit is placed in service. Reference Section 264000 for spare conduits for installation of recessed panelboards.
 12. Grounding Bushings: Grounding bushings shall be used on RMC steel conduits containing feeders that enter metallic enclosures of switchgear, switchboards, panelboards, pull boxes and junction boxes. Grounding type bushings shall be bonded together with grounding wire terminated on equipment grounding bus or when equipment grounding bus is not provided to metallic enclosure to a self-tapping screw.
 13. Sealing:
 - a. Air or Noise Seal: A minimum of 1 inch of sealing material shall be provided to prevent air movement and sound transmission via electrical conduits and wall boxes. Sealing material shall also be adequately placed in openings around conduit entering fan plenums to stop airflow. Where the conduit contains wiring, the sealing material shall be placed between interior wall of the conduit and the wire.
 - b. Fire and Smoke Seal: Holes cut by Contractor through smoke partitions, fire partitions or floors shall be sealed by Contractor. Sealant shall be of type specified in SLEEVES AND OPENINGS article in this Section 260500.
 - c. Watertight Seal: Used, empty or spare conduits stubbed up into electric and/or communications closets, or electrical equipment located on or below grade shall be sealed watertight.
 14. Aisles or Walkways: Conduits shall not be run across floor, immediately above floor or in manner that will provide hazard to people (e.g. tripping, head knocker, etc.). Conduit considered by Architect/Engineer to be mounted in manner hazardous to people shall be relocated by Contractor without cost.
 15. Accessibility: Conduits shall not block ready access to equipment, devices or a room. This includes but is not limited to cover plates, lighting fixtures, valves, air mixing boxes, doors, ladders or exit scuttles where access may be required.
 16. Homeruns: Where individual homeruns for wiring are shown on the drawings, Contractor shall not consolidate or group together wiring with other homeruns into a larger conduit and adjust wire size in accordance with NEC.
 17. Conduit for Fire Pump Feeders: Fire pump feeders shall be installed in rigid steel conduit enclosed with a minimum of 2 inch of concrete.

B. General (EMT or RMC Steel, and Rigid PVC Conduits):

1. Supports: EMT or RMC steel conduit shall be provided with galvanized steel straps, clamps, or hangers at a maximum spacing of 10 ft. for EMT, and 10 ft. to 20 ft. for RMC steel based on the conduit size in accordance with NEC. Supports for rigid PVC shall be provided using UL listed clamps in accordance with maximum spacing indicated in NEC. Conduits shall be fastened within 3 ft. of each box, cabinet or fitting. Conduits shall not

- be supported directly from ceiling T-bars, ceiling support rod hangers less than 3/16 inch, ductwork or piping, nor shall it be supported from any ductwork or piping supports that will transmit vibration.
2. Joints and Couplings: RMC steel conduit joints shall be made with threaded fittings brought up snug and tight. EMT mechanical or compression fittings shall be properly fastened and tightened. PVC conduit joints shall be made using compatible fittings. PVC coated conduit shall be brought up tight using strap wrenches to protect the PVC finish. RTRC conduit joints shall be made in strict accordance with manufacturer's instruction.
 3. RMC type raceways shall be used for following applications:
 - a. Conduit runs outside of building exposed to weather or indoor wet/hosedown areas.
 - b. Exposed conduit located in an area from floor to 8 ft. above floor in mechanical equipment rooms, electrical rooms, and loading docks.
 - c. In other rooms or areas where conduit may be exposed to possible physical damage (i.e. stage, kitchen, etc.), the conduit shall be RMC from the floor to 8 ft. above the floor.
 - d. Circuits above 600 Volts: Non-encased conduit runs for wiring above 600 volts.
 - e. Hazardous Areas: Conduit runs in hazardous (classified) locations with appropriate conduit seals in accordance with NEC.
 4. PVC coated rigid steel conduit shall be used for the following applications:
 - a. Raceways at terminal ends of PVC conduit runs below grade. This type raceway shall be placed at both ends of the PVC run. This shall include the piece through the wall and the last elbow and stub-up, except utility transformer or utility pole.
 - b. Raceway through exterior walls.
 - c. Landscape lighting circuit stub-ups.
 5. EMT steel shall be used for the following applications:
 - a. Conduit runs inside building within concrete slabs above grade with 2 inch minimum concrete encasement.
 - b. Conduit runs inside building run above ceilings and conduit stubs to above ceiling from wall outlets.
 - c. Conduit runs exposed in unfinished areas or concealed in finished areas inside building unless noted otherwise.
 - d. Conduit runs within masonry walls.
 - e. Remodeled Finished Area Raceways:
 6. Schedule 40 rigid PVC conduit shall be used for the following applications:
 - a. Conduit runs within or under concrete floor slabs located on or below grade with minimum of 2 inch concrete encasement.
 - b. Raceway for lightning protection cables from roof and through foundation to ground rods.
 7. Rigid PVC conduit and fittings shall be permitted to be surface mounted without providing air space between it and wall.
 8. EMT aluminum conduit shall be used for the following applications:
 - a. 400 Hertz power systems for computers.
 - b. MRI equipment power.
 - c. Aluminum conduit shall not be encased in concrete or laid in rock under concrete slabs.
 - d. Joints at fittings shall be treated with anti-oxidant joint compound.
- C. General (Flexible Metal and Liquidtight Flexible Metal Conduit):
1. Supports: Flexible metal and liquidtight flexible metal conduit shall be supported at maximum spacing of 4-1/2 ft. Conduits shall be fastened within 12 inch of each box or fitting. Flexible metal conduit run to recessed lighting fixtures shall be 4 ft. to 6 ft. long

and need not be supported. Conduit runs used for vibration isolation that are 3 ft. or less are not required to be supported.

2. Grounding: Flexible metal and liquidtight flexible metal conduit shall be grounded using fittings UL listed for grounding. Grounding conductors shall be provided in flexible conduits where indicated and where circuit conductors are protected by overcurrent devices above 20 amperes and where they are longer than 6 ft.
3. Liquidtight flexible metal conduit connections to small transformers, motors, control instruments, control devices, transmitters, sensors, and other instruments shall be looped to allow water to drip off and to prevent vibration transmission.
4. Flexible metal conduit shall be used for following applications:
 - a. Stud Partitions: Flexible metal conduit will be permitted for horizontal conduit runs concealed within stud partitions; however, grounding conductor shall be installed in accordance with NEC.
 - b. Conduit connections to lighting fixtures in accessible suspended ceilings to permit possible relocation of lighting fixtures after their installation.
 - c. Conduit runs in hollow metal doorjambs and window mullions where EMT cannot be used.
 - d. Conduit connections of at least 20 diameters in length to small fractional horsepower motors above accessible suspended ceilings or other dry locations.
 - e. Conduit of at least 20 diameters in length to sprinkler system water flow and tamper switches.
 - f. Branch circuit wiring to wall receptacles or modular system furniture.
5. Liquidtight flexible metal conduit shall be used for following applications:
 - a. Mechanical Equipment Connections in Wet Locations: Electrical raceway connections to mechanical equipment in equipment rooms, and connections to mechanical equipment outside the building shall be made with liquidtight flexible metal conduit.
 - b. Motor and Transformer and Generator Connections: Flexible conduit connections to motors, loose-mounted transformers and generator(s) shall be made with liquidtight flexible conduit at least 20 diameters in length.
 - c. Control Instruments, Control Devices, Transmitters, and Sensors Connections: Control instruments, control devices, transmitters and sensors requiring low voltage signal cable or 120 volt power supply shall be made with liquidtight flexible metal conduit with minimum length of 12 inch and a maximum length of 24 inch. Minimum size conduit shall be 3/8 inch.
 - d. Conduit runs for furniture feeds from poke-through floor boxes shall be with 6 ft. long liquidtight flexible metal conduit with appropriate wiring.

D. Indoor Finished Areas:

1. Concealed Conduit: Conduit in finished areas shall be concealed above ceilings or in walls.
2. Above Ceiling:
 - a. Contractor shall coordinate conduit runs above ceilings with ductwork and piping. Conduit runs shall not be installed above suspended lay-in ceilings in such a manner as to prevent removal of ceiling tile. Supports shall be in accordance with NEC.
 - b. Conduit Stubs: EMT or RMC steel conduit run from device boxes in wall and stubbed above accessible ceilings shall have insulated bushing on stub end and be located in accessible location above ceiling.
 - c. Lighting Fixtures Tap Connections: In dry locations with removable ceilings provide 4 ft. to 6 ft. of flexible metal conduit at each flush or recessed light fixture, unless they are wired via a modular wiring system.

3. Exposed Conduit:
 - a. EMT or RMC steel conduit shall be exposed in mechanical rooms, electrical closets, unfinished spaces communication rooms, manufacturing areas, elevator penthouses or machine rooms.
 - b. Conduit runs that necessitate being exposed in other areas shall be reviewed by Contractor with the Architect/Engineer prior to their installation. Contractor shall install these conduits inconspicuously as possible or use surface raceways as directed by the Architect/Engineer to maintain any architectural features.
4. Stud Partitions or Walls with Flexible Metal Conduit:
 - a. Maximum length of flexible metal conduit run horizontally between wall-mounted duplex power outlets shall be 6 ft. for areas with ceilings to 9 ft.-6 inch. Maximum length for vertical runs of flexible metal conduit shall be 10 ft. from first wall-mounted receptacle outlet box or 7 ft. from wall-mounted switch box to junction or pull box above ceiling.
 - b. Junction or pull box shall be directly above the wall-mounted receptacle outlet or switch box, near partition line. Maximum 24 inch from ceiling line. Conduit runs above ceiling from these junction or pull boxes shall be EMT.
 - c. Vertical conduit runs to outlet boxes for switches and receptacles shall be separate.
 - d. Where areas have ceilings greater than 9 ft.-6 inch maximum length for vertical runs shall be increased by difference in feet and inches between 9 ft.-6 inch and higher ceiling height.
 - e. Flexible conduit shall be secured in place and installation shall be inspected by Architect/Engineer prior to application of wall facing.
- E. Indoor Unfinished Area Conduit Work:
 1. Conduits may be run exposed in unfinished areas such as mechanical rooms, electrical closets, communications rooms, storage areas, elevator penthouses and machine rooms.
 2. Escutcheon plates shall be provided for exposed conduit passing through walls, floors and ceilings. Plates shall be nickel plated of split ring type and of size to match conduit. Where plates are provided for conduit passing through sleeves which extend above the floor surface, provide deep-recessed plates to conceal sleeves.
- F. Indoor Wet Location Conduit:
 1. Exposed wall-mounted steel conduit and fittings shall be mounted on appropriate U-type channel framing member or other similar support providing a minimum 3/4 inch air space between it and wall.
- G. Outdoor Underground Conduit Work:
 1. General: Installation shall be in conformance with conduit manufacturer's recommended practice.
 2. Missouri 1-800-DIG-RITE: Missouri law requires the Contractor to call Missouri One Call System Inc. (MOCS) not more than 10 days in advance of any excavation activity unless its an emergency situation involving danger to life, health or property.
 3. Schedule 40 rigid PVC conduit shall be used for the following applications:
 - a. Outdoor conduit runs underground in concrete encased duct banks.
 - b. Outdoor conduit runs below grade to lighting standards and landscape lighting.
 - c. Direct buried conduit.
 4. RTRC shall be used for following applications:
 - a. Outdoor conduit runs underground in concrete encased duct banks.
 - b. Outdoor direct buried conduit runs with earth backfill for site work between lighting standards, signs and parking gates.

5. RMC Steel to PVC Couplings: Couplings and RMC steel conduit at connection to Schedule 40 PVC conduit at building exterior shall be galvanized PVC coated and have threaded end to match thread of the PVC conduit. Rigid steel conduit and fittings run directly in soil shall have factory applied PVC coating.
 6. Preset Sleeves for Underground Access through New Walls or Floors: Underground conduit runs entering the building through a wall or floor below grade shall be run through oversize steel sleeve and be sealed watertight. Sleeves with wall seal fitting shall be preset inside concrete forms when penetrating poured concrete walls or foundations. Sleeves with thru-wall seals having a neoprene sealing grommet shall be O-Z/Gedney Co. (Type FSK or WSK) or Spring City Electric Manufacturing Co. (Type WEP). Where waterproofing membrane is to be installed on exterior building wall O-Z/Gedney (Type FSKA) adapters shall be used on the open end of sleeve. Wiring inside conduit shall be sealed watertight with appropriate O-Z Gedney (CSB Type) conduit sealing bushing either inside an accessible pull box or where conduit enters switchgear, switchboard, panelboard, or box.
 7. Sleeves for Underground Access through New Foundation Walls: Sleeves through foundation walls for direct buried raceway running through a foundation wall to another area where it is direct buried shall be a minimum of 2 inch larger than the outside diameter of the raceway. Raceway shall be surrounded with 1 inch of Styrofoam to help prevent damage due to settling.
 8. Duct Bank: Duct bank(s) for 4.16 kV service cables shall be provided as follows:
 - a. Conduit encased in concrete exterior to the building shall be defined as a "duct bank." Installation of concrete encased conduit shall conform to conduit manufacturer's recommended practices for concrete mix, trenching, forming, and pouring procedures.
 - b. Conduit 2 inch and larger installed underground and exterior of building shall be encased in concrete. Conduits shall be of size and type shown with approximately 3 inch separation.
 - c. Last Elbow and Conduit Stub at Stub-Up: Where PVC or fiber duct conduit is used underground, last elbow and conduit stub at stub-up above floor or concrete pad shall be Robroy PVC coated rigid steel conduit. The conduit stub-up shall be grounded.
 9. Direct Burial Conduit:
 - a. Conduit shall be direct buried for site lighting, primary and secondary service where indicated.
 - b. Minimum Depth Below Grade: Exterior underground PVC conduit containing circuits 0 to 600 volts 600 volts through 22 kV shall be no less than 24 inch below grade in areas such as parking lots, driveways, streets, alleys, or roads and no less than 18 inch below final grade in unpaved areas.
- H. Outdoor Above Ground Conduit Work:
1. RMC type raceways shall be used for following applications.
 - a. Conduit runs outside of building exposed to weather.
 - b. Circuits above 600 Volts: Non-encased conduit runs for wiring above 600 volts.
 2. Conduit shall be rigidly supported.
 3. Joints at fittings and boxes shall be adequately tightened and be watertight.
 4. Nicks, scratches, rusty spots or scrapes on RMC steel conduit or supports shall be thoroughly cleaned and repainted with galvanize paint or other corrosion resistant finish.
 5. RMC steel conduit supporting clamps and hardware shall be stainless or galvanized steel. Clamps or hardware with nicked, scraped or rusty surface shall be replaced or adequately cleaned and repainted with galvanize paint.
 6. Sleeves: Conduit entering or leaving building or structure through outside wall or roof shall be run through sleeves. Sleeves shall be sealed watertight between sleeve and wall or roof and between conduit and sleeve. Wiring inside conduit shall be sealed

watertight. Reference SLEEVES AND OPENINGS article in Section 260500 for additional details.

3.2 SURFACE RACEWAY INSTALLATION

- A. Raceways mounted on walls or casework shall be parallel to or at right angles to the building structure or casework. All exposed raceways in finished spaces shall have concealed mounting hardware and supports. Raceway shall be fastened to the wall construction on maximum 3 ft. centers. Runs less than 36 inch shall be fastened to the wall in at least two (2) places. Wider spacing may be used if installation is determined by Architect/Engineer to be mechanically rigid. Joints shall meet flush with each other and complete installation shall be neat and provide quality installation as determined by Architect/Engineer. Raceways and all items therein installed in a careless manner shall be removed, replaced and reinstalled at Contractor's expense.
- B. Number of conductors installed in raceway shall not be greater than number for which raceway, with devices, is approved. Wiring in raceway shall be neatly arranged, taped together if necessary, and clearly identified with markers or by color coding.
- C. Locations of field-installed wiring devices where shown are tentative. Contractor shall refer to Architect's or Owner's final equipment layout shop drawings for equipment locations to prevent interference with equipment and appurtenances.
- D. Locations that are in question shall be verified with Architect/Engineer.
- E. Where raceway is indicated to be run horizontally on accessible wall provide horizontally recessed wall box behind raceway system wall box connector. Recessed wall box with concealed conduit shall be located at end of raceway system run.
- F. All cutting of surface metal raceways shall be performed utilizing raceway cutters, cover cutters, and other tools and accessories specifically built by the surface raceway system's manufacturer for installation of the surface raceways specified. Under no circumstances shall hacksaws, files and similar devices be used. The shop drawings shall include descriptions of Wiremold and/or other manufacturers' tools, which the Contractor intends to utilize for this project.
- G. The entire installation shall be in accordance with the manufacturer's written installation guides for each product, and shall be included as a component of shop drawing submittals.
- H. Before beginning work, the Contractor shall arrange for specific training by the manufacturer of surface raceway products. The training sessions shall address all products specified for this project.
- I. The quality and appearance of the surface raceway installation is of paramount importance to the Owner. Any parts of the installation, which in the opinion of the Architect/Engineer, exhibit inappropriate workmanship (rough-cut joints, lack of parallelism, etc.) shall be subject to replacement at the expense of the Contractor.

3.3 OUTLET AND SWITCH BOX INSTALLATION

- A. Location:
 - 1. Reference Section 260100, MOUNTING AND LOCATIONS article for mounting requirements.
 - 2. Location of boxes shall be coordinated with devices (such as thermostats) provided by other trades. Unless otherwise approved by Architect, outlet boxes occurring at a single location shall be at an equal mounting height, to permit cover plates to align at top. Where wiring devices or other control devices in single location are too numerous to be mounted at same mounting height, multiple rows will be permitted provided they are in proper alignment. Reference INSTALLATION OF WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES article in Section 261400 for more details.

3. Heat producing devices such as dimmers shall be located 12 inch clear of heat sensitive devices (thermostats, etc.) and in separate boxes.
4. Contractor shall carefully coordinate location of boxes with casework, shelves, lavatories, showers, grab bars, mirrors and other architectural appurtenances by reviewing Architectural Drawings. Adjust location of outlet boxes in masonry walls to match masonry course lines.
5. Switch boxes, when near doors, shall be set in wall on lock side of door. Where walls are glass, boxes shall be located at a proper location. If there is any question about the location of a switch verify with the Architect/Engineer prior to installation.
6. Outlet boxes in finished areas shall be flush-mounted. Flush-mounted outlet and switch boxes shall be sufficiently recessed to allow for final wall finish.

B. Supports:

1. Boxes shall be carefully plumbed, leveled and rigidly secured so that subsequent operations of other Contractors will not cause misalignment. Supports shall be provided by Contractor to meet NEC.
2. Outlet and switch boxes shall be supported independently of conduit. Sound Isolation for Back-To-Back Boxes: Where drawings show back-to-back wiring devices, the devices on opposite sides of wall shall be offset a minimum of 6 inch and connecting raceway shall be packed with approved noise sealing material. Through-the-wall type boxes shall not be used. Noise sealing material shall be as specified under CONDUIT AND TUBING article, Manufacturer's paragraph.
3. Boxes Supporting Lighting Fixtures: Boxes used for supporting lighting fixtures up to 50 pounds shall be installed in accordance with NEC. Lighting fixtures weighing more than 50 pounds shall be supported independent of the box.

3.4 PULL AND JUNCTION BOX INSTALLATION

- A. Mounting and Accessibility:** Wiring and connectors inside boxes or box interiors in empty boxes shall be totally accessible by removing cover plate. Necessary clearance shall be provided between box and other conduit, boxes, pipes, or ductwork to allow pulling of wire or making of wiring junctions. Pull and junction boxes shall be concealed in finished areas. Interiors of pull and junction boxes in conduit runs concealed above ceilings shall be accessible by removing ceiling tile of accessible ceilings, be located behind access panels in inaccessible ceilings or be mounted with cover plate flush in the ceiling. Pull and junction boxes in walls shall have flush-mounted cover plates.
1. Pull boxes shall be installed in horizontal conduit runs of more than 100 ft. and in "power wiring" conduit runs with more than four (4) right angle bends or 360 degrees and in "voice/data" or "communication wiring" conduit runs with more than two (2) right angle bends or 180 degrees. Pull boxes shall be installed in vertical conduit runs for supporting conductors at intervals not exceeding requirements of NEC.
 2. Pull or junction boxes enclosing normal and emergency circuits shall have full height and depth steel barrier plates for separation between each type circuit. Where pull or junction boxes enclose circuits of different voltages and the insulation of the wire of both circuits is not rated to meet that of the higher rated circuit a similar barrier plate shall be provided between the circuits.
- B. Supports:** Boxes shall be appropriately secured in accordance with NEC.
- C. Outdoor or Indoor Wet Locations:** Surface-mounted boxes shall be mounted on U-type channel framing member of other support providing a minimum 3/4 inch air space between it and wall.

END OF SECTION 261300

INDEX

DIVISION 26 - ELECTRICAL WORK

SECTION 261400 - WIRING DEVICES

Article	Title	Page
PART 1	GENERAL.....	1
1.1	REFERENCES	1
1.2	GENERAL MATERIAL REQUIREMENTS.....	1
1.3	SCOPE OF WORK.....	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.7	GROUNDING AND BONDING SYSTEMS	1
PART 2	PRODUCTS.....	2
2.1	SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES	2
2.2	WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES.....	4
PART 3	EXECUTION.....	5
3.1	INSTALLATION OF SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES	5
3.2	INSTALLATION OF WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES.....	6

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SECTION 261400 - WIRING DEVICES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover wiring devices, cover plates and miscellaneous equipment, and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Outdoor and Wet Locations: Where the term outdoor is used in this section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- E. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install wiring devices, cover plates and miscellaneous equipment specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Wiring devices, cover plates and miscellaneous equipment shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Shop drawing submittals shall include but not be limited to the following:
 - 1. Switches and receptacles
 - 2. Cover plates

1.7 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with NEC.
- B. Reference Section 264500 - GROUNDING AND BONDING for grounding of power receptacles.

PART 2 - PRODUCTS

2.1 SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES

A. General:

1. Reference: Switches, receptacles and miscellaneous wiring devices shall be of type shown and as specified. Devices shall be UL listed and comply with NEMA WD1.
2. Complete Part Numbers: Listed manufacturer's part numbers in tables are to establish a type and standard of quality. Prefix and/or suffix, whether to be added or deleted to complete number, shall be Contractor's responsibility. This applies specifically but not exclusively to color identification, grade and compliance with standards and specifications. Addition or deletion of prefix or suffix to change device to lower grade will not be acceptable.
3. Grade, Quality and Substitution: Grade or qualities of devices in a category (toggle, 1 pole, duplex, conventional face, etc.) are indicated by part numbers shown as determined by Engineer. Part numbers listed by different manufacturers are equal as determined by Engineer and shall not be substituted by manufacturer or Contractor.
4. Color: Verify color of devices with Architect prior to installation. Devices shall have orange triangle for isolated ground circuits. Devices wired to emergency circuits shall be red. Color of receptacle face or switch toggle shall be that of the molding compound. Painting will not be acceptable. Reference WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES article for cover plate color.
5. Wiring: Devices shall be back and side wired using screw type terminals, unless noted SWO (side-wired-only). Pigtails will only be acceptable on GFCI type receptacles. Terminals shall accept #14 AWG through #10 AWG copper wire.
6. Wiring Device Grounding in Metal Wall Box: Reference Section 264500.
7. Manufacturer: Devices shall be by single manufacturer unless noted otherwise or where they are not commercially available.
8. Reference WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES article in this section for cover plates. Each device or group of devices mounted in single enclosure shall be provided with appropriate cover plate.
9. Sound Isolation: Reference Section 261300, OUTLET AND SWITCH BOXES article, "Indoor Box Material and Application" subparagraph for sound isolation of raceways run to outlet and switch boxes on opposite sides of walls.

- B. Switches: In general switches shall have quiet operating toggles and be 20 amps, 120/277 VAC unless shown otherwise. Switches shall comply with NEC and Federal Specification W-S-896E when commercially available. Reference preceding Complete Part Numbers paragraph for completion of table part numbers. Special devices shall be as indicated on drawings.

Manufacturer				
Device	Hubbell	Leviton	Pass & Seymour	Cooper Wiring Devices
Toggle, 1 pole	HBL-1221	1221-2	20AC1	2221
Toggle, 2 pole	HBL-1222	1222-2	20AC2	2222
Toggle, 3 way	HBL-1223	1223-2	20AC3	2223
Toggle, 4 way	HBL-1224	1224-2	20AC4	2224
Key-operated, 1 pole	HBL-1221-L	1221-2L	20AC1-L	2221L
Key-operated, 2 pole	HBL-1222-L	1222-2L	20AC2-L	2222L
Key-operated, 3 way	HBL-1223-L	1223-2L	20AC3-L	2223L
Key-operated, 4 way	HBL-1224-L	1224-2L	20AC4-L	2224L

Manufacturer				
Device	Hubbell	Leviton	Pass & Seymour	Cooper Wiring Devices
Momentary contact, SPDT with center neutral or open position	HBL-1557	1257	1251-1	1995
Maintained contact SPDT with center neutral or open position	HBL-1385 (277V)	1285	1275	2225

- C. Receptacles: In general, duplex receptacles shall be 2 pole, 3 wire, 20 amps, 125 VAC, NEMA 5-20R unless shown otherwise. Receptacles other than conventional duplex shall be as shown in following table. Receptacles shall comply with NEC and Federal Specification WC-596 when commercially available. Reference preceding Complete Part Number paragraph for completion of table part numbers. GFCI Hospital Grade or other GFCI receptacles shall not be used in hospital critical care patient areas. On ground fault they will become de-energized thus possibly removing power to a piece of life support equipment. Special devices shall be as indicated in the following "Miscellaneous Devices" paragraph or on drawings.

Manufacturer				
Device	Hubbell	Leviton	Pass & Seymour	Cooper Wiring Devices
Single, conventional face, 20A-125V NEMA No. 5-20R	HBL-5361	5361	5371	5361
Duplex, conventional face, 20A-125V NEMA No. 5-20R	HBL-5362	5362 (smooth face)	5352	5352
Duplex, rectangular face, 20A-125V, NEMA No. 5-20R	HBL-2162 (smooth face)	16352 (smooth face)	26342 (smooth face)	8362
Duplex, GFCI, rectangular face, feed through, 20A-125V, NEMA No. 5-20R	(Ivory) GF20iLA	8899	(Ivory) 2094I	XGF20
Duplex, GFCI weatherproof, "while in-use" vertical mounting, self-closing cover	FS/FD box or Std. box WP26EH		(*color)	-
Duplex, rectangular face, 20A-125V NEMA No. 5-20R with two (2) USB ports	USB 20X2	T5632	TM826 USB	TR7756

D. Miscellaneous Devices:

1. Dimmers and Occupancy Sensors: Reference Section 265700 - LIGHTING CONTROL EQUIPMENT for details on dimmers and occupancy sensors.
2. Special Devices: Refer to drawings for specifications of special purpose devices.

2.2 WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES

A. General:

1. Switch and receptacle wall plates (faceplates) shall be UL listed and shall comply with Federal Specification W-P-455 and NEMA WD-1.
2. Wall plates shall be manufactured by a single manufacturer unless noted otherwise or not commercially available.
3. Color: Wall plates of any one color shall be identical and mounting screw color shall match cover plate. Color of wall plates shall match that of the switch toggle or face of the receptacle unless otherwise indicated. Color of the plastic wall plates shall be that of the molding compound or polymeric material. Painting will not be acceptable.
4. Wall plates shall be furnished by the Contractor. Wall plates shall be provided for each switch, receptacle or miscellaneous device indicated or specified.
5. Metal wall plates shall be grounded.

B. Materials and Applications:

1. Plastic: Non-combustible, smooth finish, hi-impact, thermoplastic Nylon with reinforcing sections to provide mechanical strength at stress points. Plastic wall plates shall be used for indoor areas except those noted otherwise in following subparagraphs. Wall plates for emergency system outlets shall be labeled with word "EMERGENCY" at top.
2. Stainless Steel: Type 302 stainless steel, (18 percent chrome and 8 percent nickel, 0.032 inch thick, satin finish, smooth surface. Stainless steel wall plates shall be used for the following areas:
 - a. Food service and kitchen equipment areas
 - b. Laboratories
 - c. Schools (GFCI and standard outlets in restrooms, locker rooms and kitchen)
3. Galvanized Steel: Galvanized steel wall plates shall be used on surface-mounted boxes in unfinished indoor spaces such as elevator machine rooms, hoistways, trash and recycling rooms, mechanical rooms, and electrical and telephone closets.
4. Impact Resistant Hospital Grade: Non-combustible or self-extinguishing Noryl, smooth finish, appearance to match other plastic cover plates. Impact resistant hospital grade wall plates shall be used in conjunction with hospital grade receptacles.
5. Weatherproof Wall Plates: Weatherproof wall plates shall be installed on outlets or switches located in wet locations. Weatherproof wall plates shall have gaskets and comply with appropriate UL standards for wet locations. Wall plates on power receptacles shall be raintight while-in-use type unless otherwise indicated.
 - a. Wall plates shall be compatible with wiring device and outlet box to which they are attached.
 - b. Cover for receptacles shall open vertically unless otherwise indicated.
 - c. Wall plates for receptacles shall be spring loaded self-closing unless otherwise indicated.

C. Manufacturer:

1. Plastic and stainless steel wall plates shall be by Pass & Seymour Inc. Cooper Wiring Devices, or Mulberry Metal Products Inc. (Endura) unless noted otherwise.
2. Galvanized steel wall plates shall be provided by outlet and switch box manufacturer.
3. Raintight while-in-use wall plates for flush-mounted boxes shall be by TayMac Corp., Intermatic or Arlington Industries Inc.
4. Narrow partition switch wall plates shall be by Pass & Seymour Inc.

PART 3 - EXECUTION

3.1 INSTALLATION OF SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES

- A. General: After wiring has been installed, mount wiring devices in clean outlet boxes or surface metal raceway as indicated. Wiring shall be terminated correctly and adequately tightened. Damaged or inoperative wiring devices shall be replaced as necessary.
- B. Snap Switches: Locate light switches at the strike side of the door. Mounting of switches shall meet NEC.
- C. Power Receptacle Mounting and Location:
 - 1. Receptacle Ground Slot:
 - a. Vertically mounted single or duplex receptacles shall be mounted with ground slot up.
 - b. Horizontally mounted single receptacles shall be mounted with neutral slot on top.
 - 2. Receptacles Back-To-Back: Receptacles shall not be mounted back-to-back on opposite sides of the same wall or partition. Through-the-wall boxes are not permitted. Where they are shown back-to-back on the drawings, they shall be staggered by at least 6 inch.
 - 3. Receptacles on Columns: Receptacles shall not be mounted on centerline of structural column but be located to one side to permit the accessibility to receptacle should a future wall or partition be placed on centerline of column. When receptacles are shown on centerline of column on drawings they shall be located to left or right of column centerline as directed by Architect/Engineer.
 - 4. Clock Power Outlets: Receptacles designed for support of clocks shall be appropriately mounted to support clock.
 - 5. Coordinate mounting height of receptacles in kitchen and lab areas with equipment counter tops.
 - 6. GFCI Protected 125 Volt Receptacles:
 - a. HACR Equipment: Provide a 125 volt, 15 or 20 amp GFCI duplex power receptacle within 25 ft. of the HACR equipment and on the same level.
 - b. Receptacles Near Sinks: Duplex power receptacles within 6 ft. of sinks shall be GFCI type.
 - c. Outdoor Power Receptacles: Outdoor receptacles shall be GFCI type.
 - 7. Window Washing Equipment: Provide 120/208 volt, 20 amp receptacles around perimeter of roof for window washing equipment.
- D. Power Receptacle Wiring and Testing:
 - 1. GFCI Protected Receptacles: Where a standard GFCI power receptacle is located as the first receptacle in a branch circuit to protect other power receptacles down stream of the GFCI receptacle on the same branch circuit, Contractor shall wire in strict accordance with manufacturer's wiring diagram. Receptacles down stream shall be identified with label reading "GFCI PROTECTED".
 - 2. Receptacle Grounding to Grounded Metallic Box:
 - a. For surface-mounted boxes provide grounding continuity by installation of bonding jumpers between grounded metallic outlet boxes and receptacle grounding terminals in accordance with NEC.
 - b. For flush-mounted boxes provide grounding continuity by installation of supporting screws of the receptacle's yoke and grounded metallic outlet box.
 - c. Isolated ground type receptacle with grounding terminal shall not be bonded to the grounded metallic outlet box.
 - 3. Multiple Branch Circuits to Multiple Receptacles on the Same Yoke: Where each power outlet of a duplex outlet is wired to a separate branch circuit, the branch circuit protective device shall be a 2 pole unit to allow disconnecting of both branch circuits at the same time for safety.

4. Testing:
 - a. Power 60 Hertz receptacles shall be tested by inserting UL listed circuit tester such as Ideal (Sure Test Circuit Analyzer) or equal in each receptacle to identify loose wire connections, voltage, and proper operation of GFCI receptacles. Incorrectly wired devices shall be rewired and retested. Faulty receptacles shall be replaced.
 - b. Duplex receptacles in patient care areas shall be tested as follows:
 - 1) Visual inspection
 - 2) Ground continuity
 - 3) Polarity
 - 4) Retention force, 4 ounce minimum

3.2 INSTALLATION OF WALL PLATES FOR SWITCHES, RECEPTACLES AND MISCELLANEOUS DEVICES

- A. Install wall plate on wiring devices after walls are painted or otherwise finished. Screws used to fasten wall plate shall match wall plate color. Wall plate shall completely cover the opening and seat against the mounting surface.
- B. Where more than one device is indicated at same location, a multiple ganged, single piece wall plate shall be provided. Wall plates shall be compatible with the device configuration, size, quantity and type mounted in box. Wall plates over flush wall boxes shall meet flush with wall after being fastened in place. Where wall plates of switches, dimmers, and manual starters are in common location such as location of rooms light switches, all wall plates shall align at top. Where devices are too numerous to form single row, two (2) rows shall be provided. Vertical edge of device wall plates in bottom row shall align with vertical edge of wall plates in top row.
- C. Plates covering boxes for future systems shall be blank. Finish of wall plates shall match that of other wall plates within the room. Color of wall plate shall match that of switch toggle or receptacle face unless otherwise indicated.
- D. Jumbo wall plates shall be used for wiring devices in brick or concrete block walls.
- E. Weatherproof wall plates shall be used for wiring devices mounted in indoor wet locations and outdoor locations. Wall plates in wet locations shall be gasketed.
- F. Switch Wall Plates: Switch toggles shall not strike opening in wall plate when operated.
- G. Cracked, chipped, scratched or dented wall plates shall be replaced by Contractor as necessary at or near end of project.

END OF SECTION 261400

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 261900 – ELECTRICAL EQUIPMENT SUPPORTING DEVICES

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL SUPPORTING DEVICE REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		1
2.1	EQUIPMENT SUPPORTING DEVICES	1
PART 3 - EXECUTION		4
3.1	EQUIPMENT SUPPORTING DEVICE INSTALLATION	4

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SECTION 261900 - ELECTRICAL EQUIPMENT SUPPORTING DEVICES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL SUPPORTING DEVICE REQUIREMENTS

- A. This section is intended to cover equipment supporting devices and their installation applicable to Contractor's works.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with appropriate primer and finish to match surface prior to being cut.
- D. Outdoor and Wet Locations: Where the term outdoor is used section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- E. Equipment Series, Model or Part Numbers: Manufacturer's series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install equipment and supporting devices as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Equipment supporting devices shall be provided as called for in this specification section.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for additional shop drawings requirements for supporting devices providing vibration and seismic restraints.

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTING DEVICES

- A. General:
 - 1. Contractor shall verify the adequacy of the building supports or structure prior to hanging electrical equipment.
 - 2. Contractor shall provide appropriate anchors, supports and hardware to match the building structure and type and weight of the electrical equipment. Prior to installing fasteners and anchor bolts, the Contractor shall verify their static load limits, torque limits,

- hole size and depth, and allowable working loads in tension and shear with the manufacturer of the fasteners and anchors.
3. Contractor shall coordinate location of anchors and weight of the equipment to be installed with equipment manufacturer's installation drawings. Contractor shall install equipment with supports provided by the equipment manufacturer in accordance with manufacturer's installation drawings. Equipment and devices mounted on exterior walls or in damp or wet locations shall be mounted on U-type channel framing members to allow air circulation and help prevent rusting.
 4. Coordination: Reference Section 260100, COORDINATION article for additional coordination requirements.
 5. Equipment Supported Overhead:
 - a. General: Anchors, support rods and mounting hardware for equipment hung from overhead shall be of appropriate size and type to match overhead structure with minimum load safety factor of 4.
 - b. Load and Hangers: Trapeze type supports shall be used for hanging loads such as transformers, large size or quantity of conduit runs or cable tray (not center hung). Individual conduits may be hung from structure above with individual anchors or beam clamps and support rods with single pipe hangers.
 - c. Equipment Interference: Contractor shall provide additional trapeze type supports consisting of horizontal U-type channel framing members hung from rods anchored to building structure for spanning any interfering ductwork or piping.
 6. Wall Hung Surface-Mounted Equipment:
 - a. General: Anchors, supports and mounting hardware for wall hung surface-mounted equipment shall be of appropriate size and type to match wall construction with minimum load safety factor of 4.
 - b. Drywall Partitions:
 - 1) Heavy loads such as cabinets that are to be mounted on drywall partitions shall either be fastened across multiple wall studs or be mounted to U-type channel framing members that are anchored to multiple wall studs.
 - 2) Conduits and Boxes: Rows of conduits and associated boxes shall be fastened to U-type channel framing members anchored to wall studs. Individual conduits and boxes may be fastened directly to wall studs.
 - c. Concrete and Masonry Walls:
 - 1) Surface Mounted Conduits and Boxes: Rows of conduits and associated boxes shall be fastened to U-type channel framing members anchored to the wall with appropriate anchors. Individual conduits and device boxes may be fastened directly to the wall.
 - 2) Surface Mounted Panelboards: Surface mounted panelboard backcans located on concrete or masonry walls shall not be directly fastened to the walls but shall be mounted on U-type channel framing members anchored to walls with appropriate anchors.
 - 3) Surface-Mounted Motor Starters and Disconnect Switches: Metallic motor starters and disconnect switches located on concrete or masonry walls shall be fastened to walls on U-type channel framing members anchored to walls with appropriate anchors.
 7. Floor-Mounted Equipment:
 - a. General: Anchors and bolts for floor-mounted equipment shall be of appropriate size and type to match type floor construction with minimum shear load safety factor of 4.
 - b. Concrete Housekeeping Pad: Switchgear, switchboards, transformers, engine/generator(s), automatic transfer switches, and floor mounted panelboards and equipment racks shall be anchored to a concrete housekeeping pad.

B. Materials and Applications:

1. Indoor Dry Location U-type Channel Metal Framing Members: Indoor U-type channel metal framing members for supporting conduits, panelboards, motor starters, disconnect switches, small transformers, cable trays and boxes shall be electro-galvanized steel or have baked acrylic enamel paint applied by electro deposition.
2. Outdoor or Indoor Wet Location U-type Channel Metal Framing Members: Outdoor or wet location U-type channel metal framing members for supporting conduit, panelboards, motor starters, disconnect switches, boxes, transformers, shall be hot-dipped galvanized after fabrication unless otherwise indicated.
3. Anchors:
 - a. Interior or Exterior Masonry Walls: Provide anchors designed to match type wall construction and to withstand tension and shear loads with minimum safety factor of 4.
 - b. Interior Dry Wall: Provide toggle anchors designed to match wall type construction and to withstand tension and shear loads with minimum safety factor of 4.
 - c. Interior or Exterior Concrete Walls: Provide expansion or adhesive type anchors designed to match type wall construction and to withstand tension and shear loads with minimum safety factor of 4.
 - d. Concrete Floor: Provide expansion anchors designed to match concrete floor construction and to withstand shear loads with minimum safety factor of 4.
4. Beam Anchors and Clamps:
 - a. Concrete Beam Anchors: Provide expansion anchors designed to match concrete beam or joist construction and load in pounds placed on the anchor in tension or shear with minimum safety factor of 4.
 - b. Steel Beam Clamps:
 - 1) Beam clamps for rod supports shall be adjustable type and match beam size, hanger rod diameter and loading with minimum safety factor 4. Beam flange clamps shall be approved for seismic where available.
 - 2) Beam clamps for channel metal framing members shall match beam, channel framing member and loading with minimum of safety factor 4.
5. Support Rods: Vertical support rods shall be galvanized and threaded. Support rods shall be designed to match load in pounds placed in tension and shear with minimum safety factor of 4.
6. Hardware: In general, threaded rods, nuts, bolts, screws, and washers shall have galvanized or nickel-plated finish to prevent rusting. Hardware in indoor wet locations or outdoors shall be stainless steel. Mounting hardware shall have minimum load safety factor of 4.

C. Manufacturer: None of this equipment or anchors shall be used for seismic support unless approved by the professional engineer employed by the vibration and seismic restraint manufacturer specified in Section 262400.

1. U-Type Channel Metal Framing Members: Indoor and outdoor U-type channel metal framing members shall be by Unistrut, Building Systems Division of GTE Products Corp.; B-Line Systems Inc. (Strut Systems); Allied Tube and Conduit (Power-Strut); American Electric, FL Industries (Superstrut) or (Kindorf).
2. Anchors:
 - a. Masonry adhesive anchors from 3/8 inch to 3/4 inch shall be HILTI Type HIT. Toggle anchors of appropriate size and type are allowed for hollow masonry (concrete block).
 - b. Concrete expansion anchors in sizes from 1/4 inch to 3/4 inch shall be HILTI Type HDI. Concrete adhesive anchors in sizes from 3/8 inch to 1-1/4 inch shall be HILTI Type HVA.

- c. Self-drilling anchors for hollow block and brick shall be manufactured by Phillips (Red-Head) or Ramset Fastening Systems (RamDrill).
 - d. Self-drilling anchors for concrete shall be manufactured by Philips (Red-Head, Ramset Fastening Systems (RamDrill) or Greenlee Textron (Hanger Mate).
 - e. Self-drilling anchors (E-Z Toggle) for drywall or gypsum wallboard shall be manufactured by ITW Buildex.
 - f. Anchor bolts, toggles, etc., shall be HILTI Corp., ITT Ho-Lub; Buildex Tapcon Anchors a Division of Illinois Tool Works Inc., Metallics Inc. of Bristol, Conn. or Ramset Fastening Systems of East Alton, IL.
3. Steel Beam Clamps: Beam clamps shall be American Electric FL Industries, Steel City or Kindorf; Unistrut, Building Systems division of GTE Products Corp; Minerallic Electric Co., ERICO Fastening Products, Kee Industrial Products Inc. (Lindapter) or B-line Systems Inc.
4. Conduit support straps, clips and hangers shall be manufactured by Minerallic Electric Co. or ERICO (CADDY Fasteners). Pipe hangers shall be manufactured by Grinnell Inc. or B-Line.

PART 3 - EXECUTION

3.1 EQUIPMENT SUPPORTING DEVICE INSTALLATION

- A. Where specifications include Section 262400 - VIBRATION AND SEISMIC CONTROL all anchors shall meet that section.
- B. Provide correct size holes for wall, partition and beam anchors. Anchor bolt holes drilled in reinforced concrete beams or concrete joists shall avoid cutting reinforcing bars.
- C. Provide U-type channel metal framing members of correct size, length, type and strength to support equipment intended to be mounted to or hung from the channel framing member. Channel metal framing members shall be mounted plumb and level.
- D. Supports and electrical equipment shall be securely fastened in place. Electrical equipment shall not be hung from piping, ductwork or from hangers supporting piping or ductwork. Supports shall be designed and arranged in such manner as to avoid accumulation of dirt and dust.
- E. Unused holes for anchors in walls, partitions or beams shall be filled with appropriate material and be finished smooth.
- F. Raw edges of U-type channel metal framing members that require cutting and other outdoor supporting hangers, brackets and channels shall be cleaned and sharp edges ground smooth. Supports shall then be wiped clean and be painted with primer and finish coat. Supports of galvanized steel shall be refinished with ZRC Chemical Products Co. "Cold Galvanizing Compound" for matching a dull finish or Brite Products "Brite Zinc" galvanizing compound for matching a bright or hot-dip finish.

END OF SECTION 261900

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 261950 – ELECTRICAL IDENTIFICATION

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL IDENTIFICATION REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF REQUIRED IDENTIFICATION	1
1.5	SUBSTITUTIONS	1
PART 2 - PRODUCTS		1
2.1	NAMEPLATES	1
2.2	NAMETAPES	2
2.3	LABELS	2
2.4	WIRE MARKERS	2
2.5	CABLE TAGS	2
2.6	CONDUIT TAGS	2
2.7	COLOR-CODED TAPE	2
2.8	DIRECTORY CARD	2
2.9	BURIED WARNING TAPE	2
2.10	WARNING SIGNS	3
PART 3 - EXECUTION		3
3.1	EQUIPMENT IDENTIFICATION	3
3.2	MANUFACTURER'S NAMEPLATES	5

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SECTION 261950 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL IDENTIFICATION REQUIREMENTS

- A. This section is intended to cover identification of electrical devices and equipment and their installation applicable to the Contractor's work.
- B. Contractor shall include labor and material for furnishing and installing proper identification of electrical work as specified or indicated.
- C. Contract drawings and specification are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Unless otherwise indicated, identification by name or abbreviation shall be consistent with that shown on the drawings.
- E. All identification devices for each category such as nametapes, nameplates, labels, and warning signs shall be by a single manufacturer, be of the same size, type and coloring and have the same style lettering to provide consistency.

1.3 SCOPE OF WORK

- A. Electrical devices and equipment shall have nameplates, nametapes, labels or other identification as specified in this section.

1.4 DESCRIPTION OF REQUIRED IDENTIFICATION

- A. See PART 2 of this specification section.

1.5 SUBSTITUTIONS

- A. See Section 260100.

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Nameplates shall be placed on major electrical distribution equipment.
- B. Nameplates shall be approximately 1 inch high x 1/16 inch thick laminated plastic with beveled edges. Nameplates shall have white surface and black core to provide black lettering when engraved. After being engraved nameplates shall be mechanically attached to equipment with screws.
- C. Engraved lettering shall be a minimum 1/4 inch high and spacing between words of approximately 3/16 inch to avoid crowding. Normally, descriptions will require only a single line of lettering centered on nameplate. Where descriptions require two (2) or more lines of lettering, the description shall be separated and centered on nameplate. Multiple lines of lettering shall be separated from each other by approximately a 3/16 inch high space. Lettering shall be minimum 1/32 inch wide.
- D. Identification: Nameplates generally shall identify equipment with nomenclature corresponding to marking indicated on drawings and include system voltage. Nameplates for individual switches, breakers or motor starters shall indicate description of load served. Reference each section of specifications for additional detailed description.

2.2 NAMETAPES

- A. Nametapes shall be placed on electrical equipment, cabinets and boxes.
- B. Nametapes shall be 1/2 inch wide, black background pressure-sensitive tape similar to Rotex Dymo Tape. Identification shall indicate in white embossed lettering.
- C. Identification: Nametape lettering shall identify system or equipment by name or abbreviation and include circuit identification where applicable.

2.3 LABELS

- A. Labels shall be placed on cover plates of junction and pull boxes containing fire alarm, medium voltage or emergency system wiring.
- B. Labels shall be pressure-sensitive vinyl approximately 2-1/4 inch x 9 inch by EMED Co. Inc., Carlton Industries, Inc., LEM Products, or SETON Nameplate Co. Labels shall have black letters on orange background.
- C. Labels shall indicate system voltage and type of service, or other applicable information, (e.g., 480 VOLTS EMERGENCY or FIRE ALARM). Similar labels shall be placed on cover plates of junction and pull boxes containing medium voltage system wiring reading "DANGER - HIGH VOLTAGE".

2.4 WIRE MARKERS

- A. Markers shall be placed on control, monitor and signal wiring at all terminations in control, monitor or signal devices or equipment. Wire identification markers shall be pressure-sensitive type with surface resistive to heat 250 deg. F., abrasion, oil and dirt. Markers shall be by W.H. Brady Co. (Brady-pack), Thomas & Betts (E-Z coder) or Ideal.

2.5 CABLE TAGS

- A. All cables or conductors above 600 volts shall be identified with polyethylene cable tag holder and inserts manufactured by Almetek Industries Inc. of Ledgewood, NJ. Tags shall be placed at both terminal ends.

2.6 CONDUIT TAGS

- A. Empty conduits above the ceiling shall be identified with blank heavy-duty paper tags manufactured by Seton of Branford, CT or EMED Co. Inc. of Buffalo, NY.

2.7 COLOR-CODED TAPE

- A. Tape shall be 3M Company "Scotch 35" vinyl plastic electrical tape.
- B. Conductors: Conductor color-coded tape shall be pressure-sensitive 1/2 inch wide of color specified in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).

2.8 DIRECTORY CARD

- A. New directory cards shall be provided for each branch circuit panelboard having new circuit breakers. Utilize correction fluid or re-type a new card, scribbling out old designations or writing in card margins is unacceptable. New cards, when required, shall be on minimum 100 lb. print stock.

2.9 BURIED WARNING TAPE

- A. Warning tape, 6 inch wide tape, shall be provided below grade following the path of the underground ductbanks, conduit or cables.
- B. Location marking "red" non-detectable tape imprinted "CAUTION - HIGH VOLTAGE BURIED BELOW" shall be manufactured by Seton (573XX), Condux International Inc. or Lab Safety Supply Inc.

2.10 WARNING SIGNS

- A. Signs shall be pressure sensitive type with appropriate lettering. Signs shall be produced by Emed Co. Inc., Seton or Lab Safety Supply Inc.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

- A. General: Surface to which nametapes, nameplates, or labels, are to be applied shall be cleaned prior to their installation. Nameplates, nametapes and labels shall fit flush up against surface. Nameplates, nametapes and labels shall be centered and be square with equipment edges.
- B. Nameplates:
 - 1. Major equipment, such as switchgear, switchboards, unit substations, transformers, transfer switches, panelboards, and fuse cabinets, shall be provided with nameplates. Each fusible switch, or circuit breaker on switchgear, or switchboards shall be provided with an engraved nameplate.
 - 2. Each fusible switch or circuit breaker on switchgear, switchboards, panelboards without doors shall be provided with a nameplate.
 - 3. Service disconnects shall be provided with nameplates in accordance with Section 263000 - INDOOR SERVICE AND DISTRIBUTION ABOVE 600 VOLTS Section 264000 - SERVICE AND DISTRIBUTION TO 600 VOLTS.
 - 4. Fire alarm remote alarm lights for duct type smoke detectors shall be provided nameplates in accordance with Section 267100, FIRE ALARM SYSTEM INSTALLATION article.
 - 5. Disconnects in Wet Locations: Loose mounted outdoor or indoor wet location disconnect switches shall be provided with nameplates not nametapes.
 - 6. Motor Starters: All loose mounted motor starters shall be provided with a nameplate.
- C. Nametapes:
 - 1. Unless otherwise indicated, loose-mounted indoor dry location disconnect switches, contactors, relays, and occupancy sensors shall be identified with nametapes.
 - 2. Nametapes shall be used on junction and pull box cover plates too small for attachment of labels.
- D. Labels:
 - 1. Junction and Pull Boxes: Labels shall be placed on junction and pull box cover plates for medium voltage, fire alarm, and emergency systems. Reference paragraph C. 3. above for cover plates too small for labels.
 - 2. Warning Labels:
 - a. Cover plates for junction and pull boxes with medium voltage wiring shall have a warning label reading "DANGER - HIGH VOLTAGE".
 - b. Equipment that is started and/or stopped automatically shall be equipped with labels reading "DANGER - EQUIPMENT STARTS AUTOMATICALLY" affixed to the equipment at strategic points such as pulleys and couplings, which could cause injury upon starting of the equipment.
- E. Wire Markers: Wire identification markers shall be placed on wires to provide easy identification of wiring. Wires shall be identified in accordance with equipment wiring diagrams furnished by equipment supplier.
- F. Cable Tags:
 - 1. General: Each conductor above 600 volts shall be identified with cable tag in accordance with drawings identifying equipment and switch or circuit breaker to which it terminates. Tags shall be secured in place with Nylon self-locking ties.

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Webster University
Cannon Design Project No. 004561.01**

2. Cables terminated at switch, breakers or transformer shall be identified with cable tags having description of equipment terminated at opposite cable end. Where both pieces of equipment are within 20 ft. or less and are in view of one another, cable tags are not required.
- G. Conduit Tags: Empty conduits for future wiring shall be identified with heavy-duty tags in accordance with drawings identifying room in which it originated. Tags shall be secured in place with nylon self-locking ties.
- H. Color-Coded Tape:
 1. Conductor: Each conductor of a feeder shall be color coded its entire length or have a minimum of two (2) full turns of 1/2 inch pressure sensitive color-coded tape as specified in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS) article. Tape shall be applied on conductors between 2 and 3 inch from each terminal end and on conductors inside each junction box or pull box.
 2. Conduit: Color code conduit as follows:
 - a. Use colored tape to identify conduit by system.
 - b. Provide three (3) half-lapped wraps, minimum of 2 inch wide, minimum neatly installed around conduit at junction or pull boxes and every 20 ft. where raceway is exposed.
 - c. Fire Alarm System: Red.
 - d. Emergency Power: Blue.
- I. Panelboard Directory:
 1. New typewritten branch circuit directory cards shall be inserted within cardholder in panelboard. Contractor shall fill-in directory cards by typing Owner's final room name and identifying number as well as load description. Examples: Off. 312 Ex. Fan; Corr. 374 EWC; Stor. 963 Ltg.; Off. 731 Recept.; Tlt. 884 HTR. Room or area names and numbers shown on plans were used for design purposes only. Contractor shall verify final room or area names and numbers to be typed on each directory with the Owner.
 2. Where loads cannot be identified with a specific room, a more complete load description shall be typed.
 3. Panelboard "designation" used on Panelboard Schedule or in drawing notes shall be typed at top of each directory card.
- J. Buried Warning Tape:
 1. Warning tape shall be placed below grade to provide warning to excavators of buried electrical power or communications service cables and conduit.
 2. Buried Power Lines:
 - a. Location Marking Detectable Tape: Provide a 6 inch wide red tape identification marker 12 inch below grade directly above for full length of run. Tape shall read "CAUTION - HIGH VOLTAGE BURIED BELOW".
 - b. Location Marking Non-Detectable Tape: Provide a 6 inch wide red tape with imprint identifying marker 6 inch below grade directly above conduit for full length of run. Tape shall read "CAUTION - HIGH VOLTAGE BURIED BELOW".
- K. Warning Signs:
 1. Signs shall be appropriately fastened in place and be tight to surface to which they are attached. Signs shall be centered and square with surrounding surfaces. Reference Section(s) 263000 and 264000 for additional details.
 2. Equipment, such as switchgear located in places accessible to unqualified persons and operating at 600 volts and over, shall be equipped with signs reading "DANGER - HIGH VOLTAGE - KEEP OUT" to meet NEC requirement.
 3. Fire Pump Signs:
 - a. At Fire Pump Disconnect: Provide a sign stating "FIRE PUMP DISCONNECTING MEANS" with minimum 1 inch high letters.

- b. At Fire Pump Controller: Provide another sign at the fire pump controller stating the location of the disconnecting means and location of key if locked.

3.2 MANUFACTURER'S NAMEPLATES

- A. Disconnect switches, circuit breakers, motors, motor starters, panelboards, switchboards, transformers, and switchgear shall be equipped with legible and visually accessible nameplates giving voltage and essential characteristics, such as horsepower, wattage or current as required by ANSI or NEMA standards.

END OF SECTION 261950

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 262400 – VIBRATION AND SEISMIC CONTROL

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	SUMMARY	1
1.3	DEFINITIONS	1
1.4	PERFORMANCE REQUIREMENTS	2
1.5	COORDINATION	2
1.6	SUBSTITUTIONS	3
1.7	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	3
1.8	MANUFACTURER'S RESPONSIBILITY	3
1.9	QUALITY ASSURANCE	5
PART 2 - PRODUCTS		6
2.1	MATERIAL QUALIFICATIONS	6
2.2	FINISHES	6
2.3	DESIGN REQUIREMENTS	7
2.4	TYPE OF ISOLATION	7
2.5	SEISMIC SNUBBERS	10
2.6	HANGER MOUNTS AND SWAY BRACING	10
PART 3 - EXECUTION		11
3.1	INSTALLATION	11
3.2	SEISMIC REQUIREMENTS	12
3.3	ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION	14
3.4	INSPECTION	14
3.5	GENERAL INSTALLATION OF VIBRATION ISOLATORS FOR EQUIPMENT	14
3.6	INSTALLATION OF SUSPENDED EQUIPMENT VIBRATION ISOLATORS	15
3.7	INSTALLATION OF CONDUIT ISOLATORS	15
3.8	SEISMIC AND VIBRATION ISOLATION REQUIREMENTS	15
3.9	SOUND CONTROL REQUIREMENTS	17
3.10	INSPECTION OF VIBRATION AND SEISMIC CONTROL	18

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SECTION 262400 - VIBRATION AND SEISMIC CONTROL

PART 1 - GENERAL

1.1 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, and Section 260100 - BASIC ELECTRICAL REQUIREMENTS apply to this Section.
- B. Reference Section 261900 - ELECTRICAL EQUIPMENT SUPPORTING DEVICES for additional information on U-type channel framing members.

1.2 SUMMARY

- A. Provide vibration control and seismic restraints for Division 26 work.
 - B. Furnish submittals including details, design calculations, schedules, shop drawings, certifications and sealed cover letter for vibration isolation and seismic restraint.
 - C. Isolate vibration generating equipment from building structure by means of vibration isolators. Do not rigidly connect system components, such as distribution equipment and conduit, to vibration generating equipment unless these components are isolated through flexible connectors or vibration eliminating hangers.
 - D. Provide vibration isolators to isolate main conduit within equipment rooms from building structure by vibration isolators.
 - E. Vibration Generating Equipment:
 - 1. Vibration generating equipment shall be isolated from building structure by means of vibration isolators.
 - 2. Conduits shall not be rigidly connected to vibration generating equipment unless these components are isolated through flexible connections.
 - 3. Work shall be coordinated to avoid rigid contact between components installed by various trades. Provide corrective work necessitated by conflicts due to incorrect installation. Electrical equipment shall not be hung from piping or ductwork or from hangers supporting piping or ductwork.
 - 4. Equipment tested shall include the following. Refer to specific articles in sections indicated for additional equipment specifications.
 - a. Metal-Clad Medium Voltage Switchgear (Section 263000)
 - b. Metal-Enclosed Medium Voltage Switchgear (Section 263000)
 - c. Low Voltage Panelboards (Section 264000)
 - d. Low Voltage Switchboards (Section 264000)
 - e. Motor Control Centers (Section 264000)
 - f. Low Voltage Busway (Section 264000)
 - g. Metal-Enclosed Low Voltage Switchgear (Section 264000)
 - h. Dry Type Transformers (Section 264000)
 - i. Secondary Unit Substation Transformers (Section 264000)
 - F. Coordinate Work to avoid rigid contact to components installed by other trades. Provide corrective work necessitated by conflicts due to incorrect installation.
 - G. Correct variance or non-compliance with the specifications at no additional cost.
- 1.3 DEFINITIONS**
- A. IBC: International Building Code.
 - B. ICC-ES: ICC-Evaluation Service.
 - C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

- D. Qualified Professional Engineer: An engineer experienced in seismic design registered and licensed to practice engineering in the state of Missouri.

1.4 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Basic Wind Speed: As indicated on Structural Drawings.
 - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the electrical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
- B. Code Compliance: Seismically brace Work in accordance with Authorities Having Jurisdiction and as indicated on the Seismic Code Block on the drawings. Component Importance Factor for calculating seismic forces shall be as indicated on Seismic Code Block.
- C. Project seismic restraint requirements exceed code requirements.
- D. Work in this section includes labor, material, tools, appliances and equipment necessary for a complete vibration isolation and seismic restraint installation as indicated on drawings and in compliance with the specifications of this section. Forces shall be calculated for individual supports based on the following project criteria:
 - 1. The total height of the structure and the height of the equipment or system to be restrained within the structure shall be determined by coordination with the Architectural Plans and the General Contractor.
 - 2. Occupancy Category: As indicated on Seismic Code Block.
 - 3. Seismic Design Category: As indicated on Seismic Code Block and Structural Drawings.
 - 4. Site Classification: From geotechnical report: C.
 - 5. Spectral Response Acceleration (S_1): 0.18 – St. Louis County.
 - 6. Spectral Response Acceleration (S_S): 0.54 – St. Louis County.
 - 7. Component Importance Factor for calculating seismic forces shall be as indicated on the Seismic Code Block.
- E. Motors and transformers, within or on the building shall be isolated from building structure by vibration isolators and possibly bases.
- F. Floor and wall-mounted equipment weighing more than 200 pounds shall be anchored to the concrete pad with seismic anchor bolts isolated with neoprene bushings.
- G. Conduit Connections:
 - 1. Conduit connections to motors, transformers, and engine/generators shall incorporate liquidtight flexible metal conduit for vibration isolation.
 - 2. Conduit connections to lighting fixtures shall incorporate flexible metal conduit for isolation.
- H. Lighting Fixtures: Recessed fixtures shall be fastened to the suspended ceilings framing members with clips. Ceiling recessed or surface-mounted lighting fixtures shall be anchored to building structure above with wire hangers to prevent them from falling. Pendant-mounted light fixtures shall be provided with sway bracing and/or safety cable or chains or be located in such a manner to help prevent them from swaying or banging into other fixtures, pendant-mounted equipment or building walls during seismic action.

1.5 COORDINATION

- A. Coordinate vibration isolation and seismic restraints with final equipment selections.
- B. Coordinate housekeeping pad sizes specified in Section 260500 with anchor bolt edge clearance as detailed by vibration isolation and seismic restraint manufacturer and International Conference of Building Officials (ICBO).

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. In addition to the components identified on the drawings and in the specifications to be seismically braced, provide seismic bracing in accordance with International Building Code Referenced Standard ASCE 7-05 13.2.3 Consequential Damage.

1.6 SUBSTITUTIONS

- A. Substitutions will not be allowed except as specified in Section 260100 - BASIC ELECTRICAL REQUIREMENTS.

1.7 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Submit shop drawings for vibration isolation/seismic restraint work in accordance with Section 260100, SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS article.
- B. Submittals shall be reviewed for compliance with specifications prior to submission.
- C. Submittal shall be complete for electrical work. Incomplete submittals will be rejected for resubmittal.
- D. Submittal shall include the following:
 - 1. Cover letter from Qualified Professional Engineer: Cover letter shall state that the Qualified Professional Engineer has reviewed seismic calculations, details and shop drawings for compliance with the project seismic performance requirements and seismic design criteria.
 - 2. Seismic restraint details, calculations and shop drawings. Details, calculations and shop drawings shall be signed and sealed by a Qualified Professional Engineer.
 - 3. Details of anchorage and seismic restraints of equipment and system components.
 - 4. Anchorage Details: Include the following:
 - a. Specific information relating to the type and size of anchorage (anchor bolts, etc.). Anchorage shall be certified by manufacturer that it is suitable for dynamic seismic forces.
 - b. Specific location of such anchorage
 - c. Details of sway bracing to include:
 - 1) Materials used for sway bracing
 - 2) Attachment of the sway bracing to the structure and component being braced.
 - 3) Locations of transverse and longitudinal sway bracing and rod stiffeners.
 - 5. Seismic design provided by Contractor's Qualified Professional Engineer shall meet requirements of Article 1.9 MANUFACTURER'S RESPONSIBILITY, of this specification.
 - 6. Provide four (4) additional copies to quantities defined in Division 01.
 - 7. Provide MEP permit number with submittal.
 - 8. Submit Seismic submittals shall be submitted a minimum of 4 weeks prior to planned installation to allow for Engineer of Record's review, County's review and the County's distribution to County Inspector. Additional time may be needed if such submissions are deficient.

1.8 MANUFACTURER'S RESPONSIBILITY

- A. Manufacturer of vibration isolation and seismic restraints shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes, quantity, type and locations.
 - 2. Determine anchor bolts or other type fasteners and their embedment into building structure or concrete housekeeping pad.
 - 3. Coordinate design based on final equipment selection, and ductwork, piping and controls layout.
 - 4. Furnish calculations to determine restraint loads resulting from seismic forces.

5. Furnish design analysis in accordance with seismic requirements in accordance with Building Code. The design analysis shall take into account the total height of the structure and the height of the equipment or system to be restrained within the structure as determined by coordination with the Architectural Plans and the General Contractor.
6. Coordinate with the Structural Engineer of Record attachments and anchorage to the building structure.
7. Details: Detail attachments of seismic restraints to the restrained items and to the building structure. Show attachment locations, methods, and spacings. Identify seismic restraint components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
8. Furnish certification that seismic restraints and hanger rods have the capability to safely support loads resulting from seismic forces determined by methods defined in paragraphs above. Certification must be substantiated by calculations or test reports verified by the Manufacturer's Qualified Professional Engineer.
9. Furnish details, calculations and shop drawings signed and sealed by the Manufacturer's Qualified Professional Engineer.
10. Provide vibration isolators, seismic restraints, attachment hardware and installation tools as shown or specified for a complete installation.
11. Verify proper installation of vibration isolation and seismic restraints.
12. Furnish material certification sheets and test reports upon request.

B. Submittal Data Requirements:

1. Product Data:
 - a. Catalog cuts or data sheets on vibration isolators and specific restraints details in compliance with the specification.
 - 1) Indicate application, style, material, strength, anchorage and finish for each type and size device.
 - 2) Include load rating, deflection rating and overload capacity for each device.
 - 3) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction.
 - 4) Seismic-restraint devices shall be tested for horizontal and vertical loading and shall bear anchorage pre-approval OPA number from OSHPD, pre-approval by ICC-ES, or pre-approval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings.
 - 5) Annotate to indicate application of each product submitted and compliance with requirements.
 - b. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
 - c. Detailed schedules of equipment, piping, ductwork and controls showing vibration isolators and seismic restraints by referencing numbered details.
2. Shop Drawings:
 - a. Provide details of vibration isolators and seismic restraints: include quantity, type, size and location of each. Details shall include design of attachment hardware, reinforcement, specific anchorage and installation with relation to the building structure, system or equipment.
 - b. Provide shop drawings indicating the locations and types of vibration isolators/seismic restraints and rod stiffeners with references to specific numbered descriptive drawing details. Shop drawings shall indicate method of attachment to the building structure with details of wall, floor or other building structure to which vibration isolators or seismic restraints are attached.
 - c. Submittal shall include spacing, static loads and seismic loads at attachment and support points.

- d. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to building structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
- 3. Design Certification and Analysis:
 - a. Seismic restraint calculations shall be provided for connections of vibration isolators and seismic restraint devices. Formulas and code references shall be included.
 - b. Calculate static and dynamic seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
 - c. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 sections for equipment mounted outdoors.
 - d. Analysis shall indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and the building structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/or weld length. Seismic restraint devices shall be designed with the appropriate factor of safety, to accept without failure, the forces detailed in this section of the specification acting through the equipment's center of gravity.
- 4. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
- 5. Coordination Drawings: Show coordination of seismic bracing for electrical equipment and conduit with other systems and equipment in the vicinity, including other supports and seismic restraint. If conduit, busway, cable tray, or suspended equipment is specified to be supported with vibration isolation hangers, seismic sway bracing shall be with cable sway bracing only.
- 6. Seismic and Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in Building Code stated in PART 1 of this Section unless requirements in this Section are more stringent.
- C. Seismic restraints shall be designed by a Qualified Professional Engineer or shall be from the most current edition of one of the following manuals considered as "Accepted Engineering Practice."

1. Guidelines and Details that have been evaluated and reported under the International Code Council (ICC) Evaluation Service Program
2. Seismic Restraint Manuals, Guidelines and Details that have been approved by the California Office of Statewide Health Planning and Development (OSHPD) under their pre-approval program for anchorage and sway bracing systems.

PART 2 - PRODUCTS

2.1 MATERIAL QUALIFICATIONS

- A. Equipment shall bear manufacturer's name, trademark, ASME, UL, and other labels where a standard has been established.
- B. Equipment shall be latest approved design of standard cataloged items with factory-certified ratings.
- C. General Requirements for Seismic Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES, OSHPD or signed/sealed by a Qualified Professional Engineer as defined in PART 1 of this Section. Seismic restraints shall be selected for final equipment selection.
 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of anchorage shall be at least four (4) times the maximum seismic force to which they will be subjected as defined in code requirements for each type of seismic restraint.
- D. General Requirements for Vibration Isolation: All equipment and conduit as noted in the specification shall be supported with vibration isolation to prevent transmission of vibration and mechanically transmitted sound. Vibration isolators shall be selected in accordance with the weight distribution of final equipment selection so as to produce uniform deflections.
- E. Manufacturers: Vibration isolation and seismic restraints shall be by Mason Industries. Subject to compliance with specifications vibration isolation and seismic restraints by California Dynamics Corp., B-Line Systems, Amber-Booth, Loos or Tolco will be considered for approval. All vibration and seismic restraints shall be by one manufacturer.
- F. Restraint Cables: ASTM A 603 galvanized steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two (2) clamping bolts for cable engagement.
 1. Sway Bracing Cable: Sway bracing cable (wire/rope) strength shall exceed the maximum combined horizontal and simultaneous vertical force determined by the applied load, safety factor and angle of the cable when installed.
- G. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.
- H. Anchorage of Seismic Restraints: Anchorage of seismic restraints shall be approved by the seismic restraint manufacturer specifically for the dynamic seismic loads and as tested according to ASTM E488. Such approval shall be submitted to the Engineer.

2.2 FINISHES

- A. Vibration isolators and seismic restraints located indoors shall be provided with manufacturer's standard baked enamel or powder coated finish unless otherwise noted.
- B. Vibration isolators and seismic restraints located outdoors or indoors in wet or damp locations shall be designed or treated for resistance to corrosion.
- C. Steel components shall be PVC coated, or phosphated, and painted with industrial grade enamel. Nuts, bolts and washers shall be zinc-electroplated for exterior use or stainless steel. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. Finish coat of gray industrial alkyd enamel shall be applied over primer.

- D. Isolators exposed to weather shall have steel parts PVC coated or zinc-electroplated with an additional coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall be suitably weatherproofed etched and painted with industrial grade enamel.

2.3 DESIGN REQUIREMENTS

- A. Steel springs shall be of stable type, having horizontal stiffness at least equal to vertical stiffness. Shear stress at solid shall be sufficiently low that spring does not exceed its elastic limit and shall be certified by manufacturer for infinite cycle life classification.
- B. Floor-mounted spring isolators shall be of housed or semi-housed type for seismic restraint or of unhoused type utilized with separate seismic snubbers. Limit stops shall be provided to limit excessive vertical motion of the supported equipment when the load is reduced or when subjected to torquing or external forces. Floor mounts may be of single or multi-spring type so designed to concentrate supported load at center of support. Floor-mounted isolators shall be equipped with ribbed neoprene pad bonded to underside of baseplate. Floor mounts shall be selected so that no more than 1 inch of adjustment is required to level equipment.
- C. Hangers shall be of open or box type. Metal-to-metal contact between hanger rods and hanger box components shall be prevented through design of spring diameters and hanger box hole size, to permit hanger rod to swing through a 30 degree arc before contacting metal and short-circuiting spring. Box hangers shall be designed to withstand temporary loading equal to 400 percent of rated design load without visible deformation or failure.
- D. Where isolator mounts for floor-mounted equipment are required to be attached to equipment, frames or bases, the mounts shall be attached in a manner to maintain operating clearance of 3/4 to 1-1/2 inch under equipment base or frame.
- E. Spring isolators supporting a given piece of equipment shall be selected on basis of equal spring deflection. Therefore, spring isolators should compensate for unequal loading at various isolator locations. Equipment shall be level after operating load is applied.
- F. Isolators for equipment to be installed outdoors shall be designed to provide adequate restraint to withstand wind loading of 30 psf applied in any direction without failure of isolator.

2.4 TYPE OF ISOLATION

- A. Two layers of 3/4 inch thick neoprene pad consisting of 2 inch square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.
- B. Bridge bearing neoprene mountings shall have a minimum static deflection of 0.2 inch and all directional seismic capability. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge bearing specifications. Mountings shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.
- C. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between two (2) steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in 3 planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be Type PB as manufactured by Mason Industries, Inc.

- D. A one-piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be Type HG as manufactured by Mason Industries, Inc.
- E. Spring isolators shall be freestanding and laterally stable without any housing and complete with a molded neoprene cup or 1/4 inch neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be Type SLF as manufactured by Mason Industries, Inc.
- F. Restrained spring mountings shall have an SLF mounting within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. Installed and operating heights are equal. A minimum clearance of 1/2 inch shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Restraining Bolts shall have a neoprene bushing between the bolt and the housing. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval "OPA" Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type SLR or SLRS as manufactured by Mason Industries, Inc.
- G. Restrained air spring mountings shall have an MT air spring within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/2 inch shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be Type SLR MT as manufactured by Mason Industries, Inc.
- H. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Cables must be prestretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two (2) clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam, all as manufactured by Mason Industries, Inc.
- I. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two (2) through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "OPA" number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB, SSBS or SSRF as manufactured by Mason Industries, Inc.
- J. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of 3/4 inch thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 inch nor more than 1/4 inch. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 inch deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to 1/2 inch deflection

in the x, y and z planes. Snubbers shall have an anchorage preapproval "OPA" number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be Type Z 1011 as manufactured by Mason Industries, Inc.

- K. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying its allowable loads. Drill in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.
- L. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying its allowable loads. Drill in female wedge anchors shall be Type SAB as manufactured by Mason Industries, Inc.
- M. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 inch. The base depth need not exceed 12 inch unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2 inch bars welded in place on 6 inch centers running both ways in a layer 1-1/2 inch above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 inch clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.
- N. Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners and Kevlar tire cord frictioning. Any substitutions must have equal or superior physical and chemical characteristics. Solid steel rings shall be used within the raised face rubber flanged ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 inch and larger shall have two (2) spheres reinforced with a ductile iron external ring between spheres. Flanges shall be split ductile iron or steel with hooked or similar interlocks. Sizes 16 inch to 24 inch may be single sphere. Sizes 3/4 inch to 1-1/2 inch may have threaded two-piece bolted flange assemblies, one sphere and cable retention. Connectors shall be rated at 250 psi up to 170 deg. F. with a uniform drop in allowable pressure to 215 psi at 250 deg. F. in sizes through 14 inch. 16 inch through 24 inch single sphere minimum ratings are 180 psi at 170 deg. F. and 150 psi at 250 deg. F.. Higher rated connectors may be used to accommodate service conditions. All expansion joints must be factory tested to 150 percent of rated pressure for 12 minutes before shipment. Safety factors to burst and flange pullout shall be a minimum of 3/1. Concentric reducers to the above ratings may be substituted for equal ended expansion joints.
 - 1. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods. If control rods are used, they must have 2 inch thick Neoprene washer bushings large enough in diameter to take the thrust at 1000 psi maximum on the washer area.
 - 2. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shutoff valves. Expansion joints shall be Type SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.
- O. Housekeeping pad anchors shall consist of a ductile iron casting that is tapered and hexagonal, smaller at its base than at its top. The upper portion shall have holes for rebar to pass through. The anchor shall be continuously threaded from top to bottom for the attachment of soleplates.

Housekeeping pad anchors shall be attached to the structural slab using a stud wedge anchor. Housekeeping pad anchors shall be Type HPA and stud wedge anchor shall be Type SAS both as manufactured by Mason Industries, Inc.

2.5 SEISMIC SNUBBERS

- A. Seismic snubbers shall be designed and adjusted to prevent contact during normal operation, while providing limits to excursion of isolated equipment during seismic activity.
- B. Vibration-isolated equipment shall be mounted on rigid steel frames or concrete bases. Vibration-isolated, floor-mounted equipment shall have isolators with integral snubbers or all-directional seismic snubbers that are double acting located adjacent to isolators as required to facilitate attachment to equipment frame or base and building structure.
- C. Snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to Bridge Bearing specifications with regard to original physical properties, tests for aging, and compression set (Reference: ASTM D-412, ASTM D-573, ASTM D-1149, and ASTM D-395). Elastomeric materials shall be replaceable and minimum 3/4 inch thick.
- D. Snubbers shall be manufactured with air gap between hard and resilient materials of not less than 0.125 inch nor more than 0.25 inch. Snubbers shall be installed with factory set clearances. Capacity at 0.375 inch deflection shall be 3 to 4 times the load assigned to the mount grouping in its immediate area.
- E. Equipment shall be installed to resist seismic forces using isolators with integral snubbers, individual seismic snubbers similar to Mason Industries Z1011 or 21225 or a combination of both as directed by the manufacturer's registered engineer. Where equipment is isolated using neoprene isolators without the use of springs, Mason Industries Type BR captive mounting isolators may be used in lieu of standard neoprene isolators and separate snubbers. Anchors to structure shall be capable of withstanding seismic forces developed in restraint or snubber.

2.6 HANGER MOUNTS AND SWAY BRACING

- A. Conduit Type Hanger: Conduit type hanger shall be of appropriate size and type for support of a single conduit 2-1/2 inches and larger.
 - 1. Threaded hanger support rod shall be anchored to the structure above and be of appropriate length and strength for support of the hangers and the wire filled conduit.
 - 2. Sway bracing cables shall be of appropriate length and strength to withstand the lateral forces on the loaded hanger or conduit clamp.
 - 3. Where clevis type hangers are used and seismic bracing is attached, sleeves shall be provided on the horizontal cross bolt.
 - 4. Fasteners and anchoring devices attached to the hanger and the sway bracing cables shall be capable of withstanding the applied load and seismic forces.
- B. Trapeze Type Hangers: U-type channel framing members for trapeze hanger shall be appropriate size and type to match load and location.
 - 1. A minimum of two (2) threaded rods shall be anchored to structure above and be of appropriate length and strength for support of the load fastened to each trapeze hanger.
 - 2. Sway bracing cables shall be of appropriate length and strength to withstand lateral forces on the loaded trapeze hanger.
 - 3. Where neoprene pad with steel plate mounts for hung equipment are required to be attached to equipment frames, the isolator mounts shall be attached in manner which will isolate anchor bolt from contacting the equipment frame by use of neoprene flange type bushings.
 - 4. Anchoring devices attached to the building structure and threaded rods shall be capable of withstanding the applied load and seismic forces.
 - 5. Fasteners attached to the trapeze hanger and the sway bracing cables shall be capable of withstanding the applied load and seismic forces.

C. Recessed Lighting Fixture Hangers:

1. Recessed fixtures shall be fastened to the suspended ceilings with clips.
2. Lighting fixtures shall be fastened to the building's structure with appropriate anchors and minimum No. 12 wire. Tensile strength of the No. 12 soft annealed steel wire shall be accordance with ASTM 641.

D. Pendant Lighting Fixture Hangers:

1. Both rigid and flexible lighting fixture pendants shall be anchored to the box or structure above and be appropriate length and strength for support of the fixtures weight.
2. Sway bracing cables when required shall be of appropriate length and strength to withstand lateral forces on fixture pendant.
 - a. Sway bracing shall be required for all rigid pendants 12 inches or more from the ceiling or the building structure.
 - b. Sway bracing shall be required for all flexible pendants 12 inches or more from the ceiling or the building structure, when they can not swing more than 45 degrees from the vertical without hitting another fixture or object.
3. Lighting fixtures with rigid hollow pendants shall be large enough for both the wiring and support cable to be run through the pendant. Support cable shall be appropriately anchored to the lighting fixture on one end and to the building structure above on the other.
4. Fasteners and anchoring devices attached to the building, fixture, pendant and cables shall be capable of withstanding the applied load and seismic forces.

E. Cable Suspended Lighting Fixture Hangers:

1. Cable suspended fixtures furnished by the fixture manufacturer shall be anchored to the fixture on one end and to a hanger on the other end furnished by the fixture manufacturer. Cable and fasteners shall be Seismic Certified for 1,000 pounds (minimum) and be appropriate length and strength for support of the weight of the fixture.
2. Above the Ceiling: Seismic sway bracing shall be required for 1/4 inch x 20 inch threaded rod above the ceiling supporting lighting fixtures with flexible suspension cables. Fixture manufacturer shall provide details.
3. Below the Ceiling: Seismic sway bracing shall be required for lighting fixtures with cable (flexible) pendants 12 inches or more from the ceiling or the building structure, when they can not swing more than 45 degrees from the vertical without hitting another fixture or object.
4. Fixture cables for pendants shall be of appropriate length to support the lighting fixture assembly at the intended height.
5. Manufacturer of fixtures shall provide detailed installation drawings.
6. Fasteners and anchoring devices attached to the building, fixture, and cables for pendants shall be capable of withstanding the applied load and seismic forces.

F. Sway Bracing Cables:

1. Sway bracing cables shall be appropriately anchored to the equipment or the equipment's support on one end and to the building structure on the other.
2. Fasteners and anchoring devices used to attach the sway bracing cables shall be capable of withstanding the applied load and seismic forces at the points of attachment.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Effective vibration isolation and seismic restraint can only be achieved through proper installation. Manufacturer's field supervision shall be obtained, and manufacturer's representative shall be required to inspect installation.

- B. Vibration control and seismic bracing shall be installed in accordance with Building Code stated in PART 1 of this Section, approved component manufacturer's certified submittal data and this specification.
- C. Anchors and anchor bolts fastened to the building structure and/or concrete housekeeping pad shall be capable of withstanding the dynamic seismic loads developed in the seismic restraint. Anchorage of seismic restraints shall be as detailed by seismic restraint manufacturer.
- D. No rigid connections between equipment and the building structure shall be made that degrade the vibration isolation specified.
- E. Installation of vibration isolators shall not cause change of position of equipment, which would result in harmful stress at equipment connections to busing, wire, or raceway.
- F. Coordinate work with other trades to avoid rigid contact with the building.
- G. Any conflicts with other trades, which will result in rigid contact with equipment or conduit due to inadequate space or other unforeseen conditions, should be brought to the Architects/Engineer's attention prior to installation. Provide corrective work necessitated by conflicts after installation.
- H. Bring to the Architects/Engineer's attention any discrepancies between the specifications and the field conditions prior to installation. Provide corrective work necessitated by discrepancies after installation.
- I. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at Contractor's expense.
- J. Seismic restraints shall be positively attached to the equipment or system.
- K. Seismic (transverse or longitudinal) bracing cable shall not be installed in the same direction as solid bracing on any run for an electrical system.
- L. An electrical system shall not be braced to two (2) different parts of a building (e.g. wall and floor) at the same location since different parts of the building may act differently during an earthquake.
- M. Seismic bracing cable shall be installed such that the only visible slack is that due to the cable sag. The seismic support cables shall not support gravity loads.
- N. Install seismic bracing cables so they do not bend across edges of adjacent equipment or building structure.
- O. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
- P. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- Q. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- R. Connections to building structure shall be made with a non-friction connection.
- S. Provide anchorage to equipment, systems and the building structure in accordance with vibration isolation and seismic restraint manufacturer's approved submittals.
- T. If conduit, busway, cable tray or suspended equipment is specified to be supported with vibration isolation hangers, seismic sway bracing shall be with cable sway bracing only.

3.2 SEISMIC REQUIREMENTS

- A. All equipment, whether or not isolated, including but not limited to skid-mounted equipment shall be installed to resist seismic forces using isolators with integral snubbers, separate snubbers or bolted restraints as applicable. Equipment weighing more than 200 pounds that is bolted to

floors or pads without isolators shall be provided with oversized boltholes in equipment base or frame. Bolts shall have a neoprene bushing installed over the bolt shank to absorb shock generated by lateral impact resulting from seismic action. Anchors to building structure shall be capable of withstanding seismic forces developed in the restraint, snubber or equipment. Allowable service loads on embedded bolts shall conform to requirements of Building Code stated in PART 1 of this Section.

B. Applications:

1. Multiple Conduit Supports: Secure conduits to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD, an agency acceptable to Authorities Having Jurisdiction.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on approved component manufacturer's certified submittal data to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.
4. Provide reinforcement at seismic restraints.

C. Vibration Control and Seismic Restraint Device Installation:

1. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof penetrations.
2. Equipment Restraints:
 - a. Install seismic snubbers on electrical equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authorities Having Jurisdiction providing required submittals for component.
5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
6. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
7. Drilled-in Anchors:
 - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of

the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

- e. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - f. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.
- D. There shall be no direct restraint forces on equipment not capable of withstanding seismic loading. This type equipment shall be solidly attached to steel frames, rails and bases arranged to absorb seismic forces. Snubbers installed in conjunction with isolators shall be installed and set no sooner than 2 weeks after isolators have been in place to allow for spring creep.
- E. Adjusting:
- 1. Adjust vibration isolators after supported system is at operating weight.
 - 2. Adjust limit stops on restrained spring vibration isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
 - 3. Adjust active height of spring vibration isolators.
 - 4. Adjust leveling devices as required to distribute loading uniformly on vibration isolators.
 - 5. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in conduit runs where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 261300 RACEWAYS AND BOXES for conduit flexible connections.

3.4 INSPECTION

- A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine equipment scheduled to be supported by vibration isolators for defects that adversely affect execution and quality of work.
- C. Examine vibration isolator, seismic restraints, and attachment hardware for defects.
- D. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- E. Report unsatisfactory conditions in writing to Engineer.
- F. Do not start vibration isolation and seismic restraints work until unsatisfactory conditions are corrected.

3.5 GENERAL INSTALLATION OF VIBRATION ISOLATORS FOR EQUIPMENT

- A. Installation or use of vibration isolators shall not cause change of position of equipment or conduit, which would result in stresses in raceway connections, or misalignment of connectors, wireways or bushings. Maintain equipment and raceways in rigid position during installation. The load shall not be transferred to isolator until installation is complete and the total operating weight of the equipment is available to bear on the isolators.
- B. Where no other base is required, support isolated equipment by attaching brackets directly to equipment. Attachment shall not cause any degradation of equipment.
- C. Provide brackets to accommodate vibration isolator and provide a mechanical stop. Isolator manufacturer shall specify the vertical position and size of bracket.
- D. Minimum operating clearance between base and pad or floor shall be 3/4 to 1-1/2 inch.

- E. Place base in position and support temporarily by using shims prior to installation of machine and base assembly.
- F. Install isolators without raising equipment and base assembly.
- G. After entire system installation is completed and under full operational load, adjust isolator so that load is transferred from shims to isolator. When isolators are properly adjusted, shims shall be barely free; remove shims.
- H. Lateral motion in excess of 1/4 inch during isolated equipment startup and shutdown shall be restrained by lateral spring-type mountings.

3.6 INSTALLATION OF SUSPENDED EQUIPMENT VIBRATION ISOLATORS

- A. Install isolators with isolator hanger box as close as possible to structure.
- B. Align hanger rods to clear hanger box, hanger box to be plumb and true.
- C. Load transfer isolators, when utilized, shall temporarily maintain load in rigid position until installation is complete and fully loaded.
- D. Overhead equipment shall be suspended by number of stems required, but in no case less than four (4) stems, with vibration isolators as scheduled.

3.7 INSTALLATION OF CONDUIT ISOLATORS

- A. Conduit as set out herein shall be resiliently isolated from building. Floor-mounted supports shall have same type of isolator or media as used for nearest isolated equipment connected to conduit. Springs supporting vertical risers shall have provisions for limit stops. Isolation supplier's submittal shall clearly indicate size, loading and location of all conduit isolation supports. Any isolation submittal shall be considered partial and incomplete until such data is furnished.

3.8 SEISMIC AND VIBRATION ISOLATION REQUIREMENTS

- A. General:
 - 1. All electrical equipment (whether or not isolated) shall be installed to resist seismic forces using isolators or bolted restraints as designed by Structural Engineer and/or seismic equipment manufacturer.
 - 2. Seismic Anchors: Anchors to concrete structure shall be capable of withstanding seismic forces developed on the snubber, restraint or equipment.
- B. Conduit: Conduit for vibration isolation shall be as follows:
 - 1. Conduit Connections to Mechanical Equipment: Conduit connections to mechanical equipment shall be made with appropriate type of flexible conduit at least 20 diameters in length.
 - 2. Motor and Transformer Connections: Conduit connections to motors shall be made with specified flexible conduit at least 20 diameters in length.
 - 3. Control Instruments, Control Devices, Transmitters, and Sensors Connections: Control instruments, control devices, transmitters and sensors shall be made with specified flexible metal conduit in lengths between 12 and 24 inches. Installation shall be made in manner to allow removal of instrument, device or sensor to permit maintenance or repair.
- C. Lighting Fixtures:
 - 1. General: Unless otherwise required lighting fixtures supports shall be anchored to building structural members or structural concrete slab above.
 - 2. Recessed-Mounted Lighting Fixtures:
 - a. Recessed-mounted lighting fixtures shall be supported independent of the suspended ceiling with hangers made from wire anchored to the lighting fixture and the building structure above. Ceiling recessed lighting fixture bodies shall also

be anchored with listed clips or mechanical means by fastening to the suspended ceiling-framing members in accordance with NEC and Local Code Enforcing Authority.

- b. Ceiling recessed lighting fixtures shall be anchored with a single anchor and a wire hanger if the lighting fixture is 23 inches or less in length and less than 50 pounds. If lighting fixtures is greater than 23 inches on any one side or weighs more than 50 pounds, a minimum of two (2) anchors and two (2) wire hangers shall be provided on two (2) opposite diagonal corners. Quantities of wire hangers required are subject to approval by Local Code Enforcing Authority. Support wires shall be a minimum of No. 12 gauge (2.7 mm) soft annealed galvanized steel with a minimum of two (2) full turns at twisted attachments.

3. Pendant-Mounted Lighting Fixtures:

- a. General: Unless otherwise indicated fixtures shall be mounted not less than 7 ft. clear above floor. Fixtures shall be hung at the same height in any one room or area unless otherwise instructed by the Architect/Engineer.
- b. Fixture Above 50 Pounds: Pendant-mounted lighting fixtures weighing more than 50 pounds shall be supported independent of the suspended ceiling with support wires anchored to the fixtures outlet box and the building structure above. Support wire shall be a minimum 9 gauge (3.8 mm) soft annealed galvanized steel with a minimum of two (2) full turns at twisted attachments. Vertical support of the pendant-mounted lighting fixture shall have a minimum safety factor of 4.
- c. Sway Bracing Cables:
 - 1) Above the Ceiling: Seismic sway bracing shall be required for 1/4 x 20 threaded rod above the ceiling supporting lighting fixtures with flexible suspension cables. Fixture manufacturer shall provide details.
 - 2) Below the Ceiling: When pendant-mounted lighting fixtures have flexible pendants extending 12 inches or more from the ceiling or the building structure and they can not swing more than 45 degrees from the vertical without hitting another fixture or object, sway bracing shall be required.
 - 3) Plan View Single Pendant: In plan view lighting fixtures with a single rigid pendant or flexible pendant requiring sway bracing shall have three (3) point sway bracing cables spaced approximately 120 degrees apart.
 - 4) Plan View Two (2) Pendants: Lighting fixtures with two (2) rigid pendants or flexible pendants requiring sway bracing shall have two (2) sway bracing cables for each pendant. In plan view two (2) point sway bracing cables shall be run at 45 (±15) degrees forming approximately 90 degrees at one pendant. The other pair of sway bracing cables at the other pendant shall run in the opposite direction (approximately 180 degrees to the other cables) and be appropriately anchored.
 - 5) Elevation: In elevation the sway bracing cables shall run at 45 (±15) degrees from the horizontal axis of the lighting fixture.
 - 6) Cable Fastening: Sway bracing cables shall be fastened at bottom of pendant or as close to the fixture as possible. Where this is not possible cables may be fastened to the fixture body.
 - 7) Cable Appearance: In finished areas sway bracing cables shall be painted matte black to appear as unobtrusive as possible.
- d. Support Chain or Cable:
 - 1) Pendant-mounted lighting fixtures extending 12 inches or more from the ceiling or building structure shall have appropriate support chains or cables fastened to the fixture and the overhead structure to help prevent the fixtures from falling.
 - 2) Hollow Pendants: Where support cables are used on fixtures with hollow pendants, the support cables shall be run through the hollow pendant.

4. Cable Suspended Lighting Fixtures:
 - a. Cable suspended lighting fixtures with "seismic certified" cable mountings shall be supported from a cable hanger or canopy furnished by the fixture manufacturer on both the power end and non-power end.
 - b. Contractor shall provide junction boxes, threaded hanger support rods, support wires, anchors, etc., not provided by the fixture manufacturer.
 - c. Fixture shall be fastened to the vertical suspension cables on both ends in accordance with the manufacturer's instructions.
 - d. The hanger or canopy fastened to the structure above shall be fastened with appropriate seismic anchors and hardware.
 - e. The power cords running from above and down the suspension cable shall be neatly coiled around the suspension cables and be free of tension.
5. Surface-Mounted Lighting Fixtures:
 - a. Suspended Ceiling:
 - 1) Ceiling surface-mounted lighting fixtures on suspended ceilings shall be fastened to the main T-bar on the centerline of fixture with a support clip or to a box hanger when between T-bars. Support clip or box hanger shall be anchored to the building structural member above the ceiling with wire hangers.
 - 2) Wire hangers shall be a minimum of 12 gauge (2.7 mm) soft annealed galvanized steel with a minimum of two (2) full turns at twisted attachments.
 - 3) Minimum quantity of supports wires shall be:
 - a) Two (2) per long tube fluorescent lighting fixture (one at each end) or
 - b) Quantity equal to one less than the quantity of long tube fluorescent fixtures in a row where fixtures are rigidly fastened to one another by conduit or other devices.
 - b. Dry Wall Gypsum Ceiling: Fixture shall be supported from ceiling in accordance with NEC Article 410.
6. Wall or Bracket-Mounted Lighting Fixtures: Lighting fixtures on walls or partitions shall be anchored to structural wall or structural members within wall or partitions. Fixtures shall be rigidly fastened and snug against the wall or partition.

3.9 SOUND CONTROL REQUIREMENTS

- A. Noise Control for Wall Penetrations: Wall penetrations for electrical outlet boxes in acoustically sensitive spaces shall receive the following treatment during installation.
 1. Outlet boxes occurring on both sides of sound rated walls shall be spaced at least two (2) full stud spacing apart in stud wall construction, or 36 inches in masonry wall construction.
 2. The wall cavity behind the outlet box shall be tightly packed with lightweight glass fiber, or blown-in mineral fiber insulation.
 3. Gypsum board or masonry openings for the outlet box shall be cut to no more than 1 inch of the outlet box dimensions. The gap between the wall opening and the outlet box shall receive a urethane foam backer rod stuffed to the primary layer of gypsum board, or within 1 inch of the outer surface of the masonry. The remaining gap shall then be filled with continuous beads of acoustical sealant as defined in Article 3.10.
- B. Noise Control for Lighting Systems for Acoustical Sensitive Areas:
 1. Fluorescent lighting specified for spaces possessing noise criteria rating of NC-40 or less shall possess Noise Class A rated ballasts. Any ballast for fluorescent lighting fixtures, which cause the noise criteria for any space to be exceeded, shall be replaced by the Contractor at no additional cost to the Owner. If two (2) replacements do not produce

acceptable results, provisions shall be made for remotely mounting the ballasts in adjacent non-noise sensitive areas.

2. Metal-halide, high-pressure sodium or other types of high intensity discharge (HID) lighting fixtures specified for use in spaces with noise criteria of NC-45 or less shall possess the following characteristics:
 - a. Ballast housings shall consist of minimum 16 gauge sheet steel on suitably rigid framework welded to form a complete enclosure.
 - b. The transformers shall be rigidly mounted in the ballast enclosure, and the enclosure shall be filled with a dense non-conduction (i.e., polyester-silica mixture) encapsulant.
 - c. The ballasts shall be remotely mounted from the lamp and reflector assemblies within the space served. Flexible conduit and or wiring connections shall be made connecting the two (2) components.
 - d. The Contractor shall be fully responsible for implementing remedial measures necessary for lighting fixture noise control, where fixture/ballast replacement or remote mounting of ballasts is required.

3.10 INSPECTION OF VIBRATION AND SEISMIC CONTROL

- A. Vibration and seismic restraint manufacturer or his representative and the structural Engineer shall examine the installation of mechanical equipment for the quality of work, missing supports or other defects that will adversely affect the vibration and seismic control systems. Examination shall include but not be limited to the following:
 1. Examine the installation of equipment to be supported by vibration isolators, hangers and any seismic restraints for missing supports and other defects.
 2. Examine the installation of ceiling mounted equipment and devices to be supported by hanger wires for missing hanger wires, ceiling clips, supports and other defects.
 3. Examine the installation of equipment/components support from building structure for quantity and type(s) of seismic restraints, and anchors and the flexible conduit connection.
 4. Examine the installation of floor or pad-mounted equipment for correct quantity and type vibration isolators, seismic restraints, anchors and anchor bolts.
 5. Examine the wall-mounted equipment for correct quantity and type seismic restraints and anchors.
 6. Measure vibration isolator restraint clearance.
 7. Measure vibration isolator deflection.
 8. Verify snubber minimum clearances.
 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- B. Vibration and seismic restraint manufacturer or manufacturer's representative shall report unsatisfactory conditions in writing to the Engineer.
- C. Vibration and seismic restraint manufacturer or manufacturer's representative shall make a final inspection and submit written report to the Architect/Engineer certifying a correct installation, performance in compliance with approved submittal data.
- D. Contractor shall not continue installation work until unsatisfactory conditions are corrected.
- E. If Owner or his representative reports objectionable noise or vibration, arrange for field instrumentation testing and measurements by independent acoustical consultant to determine source, cause, and path of disturbance. Non-compliance with these specification requirements to the extent that noise or vibration can be attributed to vibration isolators or this portion of the work shall be corrected at no additional cost. Remove and replace malfunctioning devices and retest as specified above.

END OF SECTION 262400

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 264000 – DISTRIBUTION (TO 600 VOLTS)

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL POWER DISTRIBUTION REQUIREMENTS	1
1.3	SCOPE OF WORK	2
1.4	DESCRIPTION OF SYSTEMS	2
1.5	SUBSTITUTIONS	3
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	3
1.7	BUILDING SYSTEM VOLTAGES	3
1.8	GROUNDING AND BONDING SYSTEMS	3
PART 2 - PRODUCTS		4
2.1	AUTOMATIC TRANSFER SWITCHES (ATS)	4
2.2	DISCONNECT SWITCHES	7
2.3	DRY TYPE SECONDARY UNIT SUBSTATION TRANSFORMERS (300 KVA THROUGH 2500 KVA)	9
2.4	ELEVATOR POWER MODULE SWITCH	11
2.5	FUSES (TO 600 VOLTS)	12
2.6	LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS	13
2.7	LOW-VOLTAGE DRY TYPE TRANSFORMERS (500 kVA AND BELOW)	16
2.8	PANELBOARDS (CIRCUIT BREAKER AND FUSIBLE SWITCH)	17
2.9	SECONDARY UNIT SUBSTATIONS	20
2.10	UNIT SUBSTATION LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS	23
PART 3 - EXECUTION		26
3.1	AUTOMATIC TRANSFER SWITCH INSTALLATION AND TEST	26
3.2	DISCONNECT SWITCH INSTALLATION	27
3.3	DRY TYPE SECONDARY UNIT SUBSTATION TRANSFORMERS (300 KVA THROUGH 2500 KVA) INSTALLATION AND TESTS	27
3.4	ELEVATOR POWER MODULE SWITCH INSTALLATION	28
3.5	INSTALLATIONS OF FUSES (TO 600 VOLTS)	28
3.6	INSTALLATION OF LOW-VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS	29
3.7	LOW-VOLTAGE DRY TYPE TRANSFORMERS (500 kVA AND BELOW) INSTALLATION AND TESTS	29
3.8	PANELBOARD (CIRCUIT BREAKER AND FUSIBLE SWITCH) INSTALLATION	31
3.9	SECONDARY UNIT SUBSTATIONS INSTALLATION AND TESTS	32
3.10	INSTALLATION OF UNIT SUBSTATION LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS	34

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SECTION 264000 - DISTRIBUTION (TO 600 VOLTS)

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL POWER DISTRIBUTION REQUIREMENTS

- A. This section is intended to cover distribution system(s) to 600 volts and installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and as required for complete and proper performance of materials, equipment and systems.
- C. Equipment shall conform to the latest revised applicable NEMA and ANSI standards.
- D. Contractor shall receive, handle, store, install, and assemble equipment specified in accordance with manufacturer's instructions and recommendations. One copy of these instructions shall be included with equipment at time of shipment.
- E. Equipment Storage and Protection:
 - 1. In general, distribution equipment shall be stored in sheltered, clean, dry area. If equipment must be stored in cool or damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect distribution equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosures shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense.
 - 2. Until final observation equipment bus bars, terminals and other internal components shall be protected by Contractor from paint, plaster, cleaners, abrasives, dust and spray by providing appropriate covers.
- F. Identification: Equipment and components shall be identified in accordance with Section 261950 - ELECTRICAL IDENTIFICATION.
- G. Type Connectors: Feeders to 600 volts terminated on bus bars within distribution equipment shall be made with either factory-installed lugs listed by UL for minimum of 167 deg. F. as part of the assembly or field-installed connectors. All connectors used shall be the same type and by the same manufacturer. Low voltage field-installed lugs shall be as specified in Section 261200, WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS) article.
- H. Torque Values of Connections: Contractor shall verify torque value of factory made connections and his field connections (cable connector to bus bar, bar to bar, and bus bar supports) within service and distribution equipment meet manufacturer's recommended values.
- I. Space Requirements: Contractor shall be responsible for determining both physical and working space requirements for equipment by manufacturers other than that of first-named manufacturer or manufacturer on which drawings were based.
- J. Certified Test Report of Ground Fault Protection System: Ground fault protection devices on fusible switches or circuit breakers shall be performance tested and results recorded. Contractor shall provide Architect/Engineer with Certified Test Report in accordance with Section 260100, TESTING article four (4) weeks prior to his final observation indicating that tests have performed free of malfunctions. Contractor shall include record data of tests for each ground fault protection system on service equipment for certification of test.
- K. Concrete Housekeeping Pads: Concrete pads shall be provided in accordance with the requirements in Section 260500, CONCRETE WORK article.

L. Seismic Requirements:

1. Equipment shall be installed to prevent lateral movement and uplifting of equipment under seismic conditions.
2. Reference appropriate equipment articles this section and section 262400 - VIBRATION AND SEISMIC CONTROL article for additional details.

M. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis for minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that the newest equivalent series, model or part shall be furnished.

N. New Circuit Breakers: Circuit breakers shall be new and not be reconditioned, rebuilt or remanufactured type. Manufacturer and supplier shall ensure that breakers can be traced to their original manufacturer.

1.3 SCOPE OF WORK

A. Contractor shall furnish and install following 600 volt distribution equipment:

1. Unit substations
2. Transformers (dry type)
3. Low voltage switchboards
4. Panelboards
5. Motor controllers
6. Disconnect switches
7. Fuses (to 600 volts)
8. Automatic transfer switches (ATS)

1.4 DESCRIPTION OF SYSTEMS

A. Following is general description of the required power distribution equipment and devices:

1. Unit Substations:
 - a. Unit substation(s) will be 5 kV switches, dry type transformer and a line-up of secondary circuit breaker switchgear.
 - b. Substation secondaries will be 277/480 volt, 3 phase, four-wire to provide electrical power for all mechanical equipment, and lighting and primary side of 120/208 volt transformers.
 - c. Secondary main will be draw-out power circuit breakers in a switchgear cubicle. Molded case circuit breakers will be used on distribution sections for feeder protection and disconnection.
 - d. Secondary mains will be fusible bolted pressure switches. Fusible switches both bolted pressure and QMQB type will be used on distribution sections for feeder protection and disconnection.
2. Distribution Switchgear: Switchgear will be fusible switch or circuit breaker type as indicated on drawings to provide distribution, disconnection and overcurrent protection of feeder wiring.
3. Switchboards: Switchboards will be fusible switch and circuit breaker type to provide distribution, disconnection and overcurrent protection of feeder wiring.
4. Loose-Mounted Transformers: Transformers provide reduction in voltage to 120/208 volts for panelboards providing power for duplex receptacles and incandescent lighting.
5. Panelboards: Circuit breaker (CB) panelboards will provide distribution and overcurrent protection of branch circuit wiring.
6. Mini-Power Center: Mini-power system consisting of a combination transformer and CB panelboard will provide voltage reduction, as well as, distribution and overcurrent protection of 120 and 208 volt branch circuit wiring.
7. Automatic Transfer Switches (ATS): ATS will provide starting signal to engine/generator(s) and switching of emergency lighting, fire alarm system, EMCS

system and other critical loads to emergency generator power upon loss of normal utility power.

8. Motor Controllers and Disconnects: Provide loose mounted combination motor controllers with fusible disconnect switches and manual starters for pumps and fans as indicated.
9. Infrared Thermographic Inspection and Report: Contractor shall provide an infrared thermographic inspection and report on all equipment provided.

1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Space Allocation: Both physical and working space allocation indicated for equipment to 600 volts is based on first-named manufacturer. In event physically larger equipment is furnished, Manufacturer and Contractor shall be responsible for making detailed installation drawings of equipment in an organized manner to match the allocated space prior to shipping any equipment.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to the following:
 1. Unit substations 5 kV switches and fuses
 2. Transformers (dry type)
 3. Low voltage switchboards
 4. Panelboards
 5. Loose motor controllers
 6. Disconnect switches
 7. Fuses (to 600 volts)
 8. Nameplates
 9. Automatic transfer switches (ATS)
 10. Time Current Curves: Manufacturer shall supply time current curves for all circuit breakers and fuses used on job with shop drawings. Both breaker and fuse curves shall be on same size of transparent standard time, current, log paper to allow overlays.

1.7 BUILDING SYSTEM VOLTAGES

- A. Main Power Distribution: 600 volt distribution for the building shall be 277/480 volt, 3 phase, four-wire, grounded wye.
- B. Power for Building Mechanical Equipment: In general power shall be 480 volt, 3 phase.
- C. Miscellaneous lighting and power shall be 120/208 volt, 3 phase, four-wire, grounded wye provided by step-down transformers distributed through panelboards.
- D. Kitchen power shall be 120/208 volt, 3 phase, four-wire, grounded wye provided by step-down transformer.

1.8 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical equipment shall be provided in accordance with NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for additional details on grounding of equipment to 600 volts.

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES (ATS)

A. General:

1. Provide automatic transfer switches with voltage and ampere ratings, controls and pilots in NEMA 1 enclosures as indicated.
2. Transfer switches 400 amperes and above shall be capable of switching all classes of loads, i.e., resistive, tungsten, ballast, and inductive loads.
3. Standard: Transfer switches shall meet latest revised requirements of UL 1008 and withstand and closing ratings (WCR) listed. Switches shall be installed in accordance with Article 700 of the latest National Electric Code.
4. System Description:
 - a. Engine starting time-delay relay contacts in any transfer switch shall operate to start engine generator(s), when any phase of normal power source feeding a transfer switch drops below 80 percent of its normal input voltage for one second.
 - b. As soon as generated emergency power reaches 90 percent of the rated voltage and 90 percent of 60 cycle frequency, on the failed normal source, transfer switch time delay relays (TDR) will start timing out, and shall start the transfer to emergency power after the time setting has elapsed.
 - c. Time delay transfer relays in transfer switch(es) will operate and start transfer of the load to generator power at 3 second timed intervals in priority order assigned by Owner.
 - d. After restoration of normal power on all phases to 90 percent of rated voltage, time-delay return relays shall control retransfer back to the normal utility power.
 - e. After all systems have been retransferred to the normal source, engine/generator(s) shall operate at no-load for several minutes before shutting down to allow the generator to cool down.
5. Warranty: Manufacturer shall provide warranty on automatic transfer switches to cover labor and material for one year(s) from date of acceptance by Owner.
6. Field Engineer: Manufacturer of ATS shall provide field engineer for standby power system startup test and acceptance test and automatic transfer switch test. Reference Section 266500, Standby Power Engine/Generator article for additional details.

B. Materials and Applications:

1. Electric Operator:
 - a. Transfer switches shall be self-acting, quick-make, quick-break, electrically operated, mechanically held 3 or 4 pole switch as indicated.
 - b. Transfer switches shall be interlocked mechanically and electrically to prevent closing of both the normal and alternate power sources at the same time unless closed transition transfer (CTT) is indicated. Electrical interlocks shall be wired to operate from normal or emergency power.
 - c. Operation of switches shall be either single momentarily energized operator, bi-directional motor operator or linear motor operator.
 - d. Operation of switches shall be by dual motor operators when required to be controlled by load shedding relays.
 - e. Open Transition Transfer (OTT): Interlocking shall prevent the normal and emergency contacts from closing simultaneously.
 - f. Transfer switches shall be capable of transferring in either the normal or emergency mode with 85 percent of rated voltage available. Emergency Source transfer time delay relays (TDR) and Normal Source return TDRs shall have adjustable voltage pickup and dropout and where ranges are indicated they are minimum. These time delay relays shall have adjustable pickup voltage of 85 to 100 percent of line voltage and adjustable dropout voltage of 75 to 90 percent of pickup setting.

- g. Transfer switches, except those having in-phase monitoring or programmed transition, shall have transfer time not to exceed 1/2 second after receiving signal from the emergency source or the normal source time delay relay to initiate the closing.
- 2. Manual No-Load Operator: Transfer switches shall have following manual operation provisions.
 - a. External key-operated test switch to test automatic transfer switch by simulating normal power failure.
 - b. Manual operating handle to be used only for installation, maintenance and emergency operation.
- 3. Main Contacts:
 - a. Main contacts shall be made of silver-tungsten alloy rated for continuous duty.
 - b. Arcing contacts with arc chutes shall be provided to protect the main contacts.
 - c. Main contacts shall be visually inspectable without major disassembly or disconnection of power conductors.
 - d. Size of main contacts shall be as indicated.
 - e. Unless otherwise indicated fully rated neutral contacts on the fourth pole matching the three (3) power phase poles shall be provided.
- 4. Accessories:
 - a. Test Switch and Pilot Lights: Key operated test switch shall be mounted on ATS door and have 2 positions with switch mode pilot lights. Pilot lights shall be green to indicate when ATS is closed on normal power and red when ATS is closed on emergency power. Test switch positions shall be labeled GENERATOR START TEST and AUTOMATIC. The test switch GENERATOR START TEST position shall be momentary and switch the AUTOMATIC position shall be maintained. In GENERATOR START TEST position the ATS shall operate as if it had a power failure on its normal power source. The ATS will signal generator(s) to start and come up-to-speed, however, ATS will not transfer load to emergency unless there is a true normal source power failure.
 - b. Auxiliary Contacts: Auxiliary contacts shall be provided in each transfer switch for following:
 - 1) RAA Contacts: For remote annunciation wiring to a remote alarm annunciator (RAA).
 - 2) Elevator Signal Contacts: For signaling appropriate elevator controller(s) to provide one car at a time operation per elevator bank while elevators are powered by emergency generators.
 - 3) Engine Starting Contacts: Engine starting contacts shall be provided in all transfer switches to start engine/generator when any phase of normal source drops below 80 percent of rated voltage for one second. This shall be accomplished by adjustable close differential relays and adjustable time-delay.
 - c. Switching Transformers and Motors: Transfer switch(es) for equipment Priority No. 2 loads (transformer and motor loads) shall have neutral programmed transition by using time delay when transferring from neutral to emergency or neutral to normal, between opening of one set of contacts and closing of other. Time delay shall provide enough time for transformers voltage to decay and motors to come to a complete stop before re-energizing.
 - d. Accessibility: Relays, timers, control wiring, and accessories shall be accessible from front of enclosure with door open.
- 5. Minimum Short Circuit Withstand and Closing Ratings (WCR):
 - a. Transfer switches shall have short circuit withstand capability of 33,000 amps rms symmetrical for three (3) cycles when tested alone (without current limiting fuses).

- b. Transfer switches shall have short circuit withstand and closing rating as listed below when tested at 480 VAC in conjunction with molded case circuit breakers. Where these ratings differ from the latest UL 1008 the stricter rating shall apply.

100	-	150 amperes	-	16,000 RMS amps symmet.	-	1.5 cycles
	-	225 amperes	-	20,000 RMS amps symmet.	-	1.5 cycles
	-	400 amperes	-	35,000 RMS amps symmet.	-	3 cycles
600	-	800 amperes	-	40,000 RMS amps symmet.	-	3 cycles
1000	-	1600 amperes	-	50,000 RMS amps symmet.	-	3cycles
	-	2000 amperes	-	65,000 RMS amps symmet.	-	3 cycles
	-	3000 amperes	-	73,000 RMS amps symmet.	-	3 cycles

6. Initial Relay Settings: Initial voltage, frequency, and time delay relays (TDR) settings shall be as follows:

- a. Transfer to Emergency Generator Power: Elapsed time starts on loss of utility or normal power source.

Total Elapsed Time	Function	TDR Relay
0 sec.	When normal power source on line-side of any ATS drops below 80 percent of rated line voltage for one second, the engine shall be signaled to start.	Normal Source time-delay relay in any transfer switch.
1 sec.	Engine starts.	Engine Start TDR (TDR 0-6 sec.) set at 1 sec.
8 sec.	When engine/generator reaches 90 percent of rated voltage and frequency, transfer switch(es) shall, after time delay indicated, start transfer operation to emergency generator power.	Emergency Source Transfer TDR (TDR 0-120 sec.) set at 8 sec.
10 sec.	Equipment Load Priority No. 3 transfer switches shall start transfer to emergency generator power.	Emergency Source Transfer TDR (TDR 0-120 sec.) set at 10 sec.

- b. Retransfer to Normal Power after being on Generator Power: Elapsed time starts on return of utility or normal power source.

Total Elapsed Time	Function	TDR Relay
0 min.	Normal power reaches 90 percent of rated voltage and frequency retransfer normal source TDR relay begins timing out.	Normal Source Relay in any transfer switch
15 min.	Priority No. 3 Equipment Load transfer switch(es) shall start to transfer back to the normal source.	Normal Source Return TDR (TDR 0-30 min.) set at 15 min.
18 min.	Transfer switches shall start transfer operation back to the normal source.	Normal Source Return TDR (TDR 0-30 min.) set at 18 min.

- c. Engine Shutdown after Operating Under No-load: Elapsed time starts after all associated ATSS return loads back to utility or normal power source.

Total Elapsed Time	Function	TDR Relay
18 min.	After retransfer of load(s) back to normal power, engine will run for the cooling down period.	Shutdown TDR (TDR 0-10 min.) set at 5 min.
15 min.		
23 min.	After cooling down period the TDR will operate to shutdown the engine.	

7. Final Relay Settings: Final time delay settings shall be as determined by Engineer. Contractor shall change settings according to Engineer's instructions.

- C. Manufacturer: Automatic transfer switches shall be UL listed to meet these minimum specifications. All switches shall be by the same manufacturer. Transfer switches shall be products of Russelectric Inc, Onan Corporation, Zenith Controls Inc. or ASCO (Automatic Switch Co.).

2.2 DISCONNECT SWITCHES

A. General:

1. Disconnect switches for motor and power loads shall be furnished by the Contractor unless otherwise noted. Switches shall be rated 240 VAC or 600 VAC for appropriate circuits.
2. Switch doors shall have provisions for padlocking closed. Switch operating handle shall have provisions for padlocking in OFF position. Safety switches shall have interlock to prevent unauthorized opening of switch door while switch is ON. Provision for defeating interlock for authorized inspection shall be provided.
3. Codes and Standards: Switches shall meet NEC for wire bending space. Switches for motors shall meet NEC.
4. Auxiliary Contacts: Disconnect switches shall be provided with auxiliary contacts, where they are required to disconnect control circuits having a power source different than motor or power load being switched.
5. Switches mounted indoors shall have NEMA 1 enclosures.
6. Switches mounted outdoors on roofs for fan disconnects shall have NEMA 3R, non-ventilated, raintight enclosures.

B. Materials and Applications:

1. Three Phase 240 or 600 Volt Motor or Power Loads (Three-Pole Safety Switches):
 - a. 30 Through 1200 Amps: Disconnect switches for 3 phase motor or power loads shall be three-pole, quick-make, quick-break, heavy duty type, 80 percent rated, "safety switches", horsepower rated and UL listed. Switches shall have 167 deg. F. lugs and be rated for 240 VAC or 600 VAC as appropriate. Fused disconnect switches shall have 100,000 amperes RMS symmetrical withstand rating and have Class J fuses.
 - b. 1600 Through 4000 Amps: Disconnect switches for 3 phase loads shall be three-pole, 100 percent rated, "bolted-pressure" or "high-pressure" contact type and be UL listed. Fused disconnect switches shall have 200,000 amperes RMS symmetrical with stand rating and have Class L fuses.
 - c. Fusible and Non-Fusible: Switches 30 to 600 amps shall normally be non-fused type; however, when indicated to be fusible, fuses shall be in accordance with Fuses (To 600 Volts) article.

2. Single Phase 240 Volt Motor or Power Loads (Two-Pole Safety Switches):
 - a. 30 Through 1200 Amps: Disconnect switches for single phase motor or power loads shall be two-pole, quick-make, quick-break, heavy duty type, 80 percent rated, "safety switches", horsepower rated and UL listed. Switches shall have 167 deg. F. lugs and be rated for 240 VAC.
 - b. Fusible and Non-Fusible: Switches 30 to 1200 amps shall normally be non-fused type; however, when specified, a fusible, fuses shall be in accordance with Fuses (To 600 Volts) article.
3. Single Phase 120 Volt Motor Loads (Single-Pole Non-Fusible Toggle Switches):
 - a. Manual Controller Disconnect Switch: Manual controller toggle switches for single phase motor loads shall be non-fused type as follows:
 - 1) Single-pole, non-fusible, manual controller toggle switches for single phase 120 volt, maximum 1 horsepower motor loads use 20 amp horsepower rated switches.
 - 2) For larger horsepower motor loads or fusible disconnects, use disconnect switches as specified above for 3 phase motor loads.
 - 3) Switches shall be maintained AC toggle type without pilots and motor overloads.
 - 4) Surface-mounted switches shall have switch lockout cover plate.
 - b. Other Type Disconnects: For each single phase motor 125 volts or less provide as indicated one of the following:
 - 1) Manual motor starter with overloads.
 - 2) Reference Motor Controllers article this section for specifications of preceding b1.
4. Single Phase 240 Volt Motor Loads (Two-Pole Non-Fusible Toggle Switches):
 - a. Disconnect Switch: Disconnect switches for single phase motor loads shall be non-fused type as follows:
 - 1) Two-pole, non-fusible, toggle switches for single phase 240 volt, maximum 2 horsepower motor loads use horsepower rated switches.
 - 2) For larger horsepower motor loads or fusible disconnects, use disconnect switches as specified above for 3 phase motor loads.
 - 3) Switches shall be maintained AC toggle type without pilots unless otherwise indicated.
 - b. Other Type Disconnects: For each single phase motor 600 volts or less, provide as indicated, one of the following:
 - 1) Magnetic starter (Non-Combination type) with separate fused disconnect switch.
 - 2) Magnetic starter (Combination type) with fused switch.
 - 3) Reference Motor Controllers article this section for specifications of preceding b1. and b2.
5. Single Phase 120 or 277 Volt System Power Loads (Single-Pole Non-Fusible Toggle Switches): Single-pole toggle switches for single phase power loads at maximum of 1000 watts for 120 volts and 4000 watts for 277 volts shall be appropriate 20 amp, single-pole, AC maintained contact toggle switches. Switches shall be without pilots unless otherwise indicated. Two-pole disconnects for larger single phase power loads use one of the disconnects as specified above.

C. Manufacturer:

1. Three Phase Motor and Power Loads:
 - a. 30 Through 1200 amps: Manufacturer of 600 VAC and 240 VAC Heavy Duty, three-pole safety switches shall be Square-D (Heavy Duty Class 3110), General Electric (Type TH), Siemens (Type VBI0 Heavy Duty), or Eaton Corp. (Type DH).
 - b. 1600 Through 4000 Amps: Manufacturer of 600 VAC, three-pole switches shall be General Electric "High-Pressure Contact" type, or Pringle "Bolted-Pressure" type.
2. Single Phase Motor or Power Loads: Manufacturer of 240 volt safety switches shall be Square-D, Eaton Corp., General Electric, or Siemens.
3. Single Phase Motor Loads:
 - a. Manual Controller (No Overload Protection):
 - 1) Toggle switches rated for 120 volt motors shall be SPST rated at minimum 20 amps, 120/277 volt for single phase motors and be manufactured by Pass & Seymour PS20AC2-HP or Hubbell HBL3031.
 - 2) Toggle switches for 240 volt motors shall be DPST rated at minimum 20 amps, 277 volts for single phase motors and be manufactured by Pass & Seymour PS20AC2-HP or Hubbell HBL3032.
4. Single Phase Power Loads: Toggle switches for power loads shall be Pass & Seymour PS20AC1 or PS20AC2 series.

2.3 DRY TYPE SECONDARY UNIT SUBSTATION TRANSFORMERS (300 KVA THROUGH 2500 KVA)

- A. General: This article describes unit substation ventilated dry type NEMA Class (AA/FA), vacuum pressure impregnated cast coil. Transformer shall be indoor type with standard indoor enclosures.
1. Standards: Transformers shall be tested in accordance with latest revision of ANSI Standard Test Code for Transformers. Transformers shall be built in accordance with latest revised IEEE, ANSI and NEMA standards.
 2. Factory Test: Transformers shall be factory tested in accordance with applicable NEMA and ANSI standards. Certified test reports shall be supplied to Architect/Engineer. Reference Section 260100, TESTING article for details.
 3. Submittals: The following information shall be submitted to the Architect/Engineer for approval prior to shipment for each transformer.
 - a. Dimension drawing and weight
 - b. Technical certification sheet
 - c. Conduit entry/exit locations
 - d. Transformer ratings including:
 - 1) kVA
 - 2) Primary and secondary voltage
 - 3) Primary taps
 - 4) Primary and secondary continuous current
 - 5) Basic Impulse level for equipment over 600 volts
 - 6) Impedance
 - 7) Insulation class and temperature rise
 - 8) Sound level
 4. Electrical Ratings:

a. kVA	Reference Drawings
b. Impedance	5.75 percent (plus or minus 7-1/2 percent)
c. High Voltage (Primary)	4.2 kV

- | | | |
|----|-------------------------|---|
| d. | High Voltage | 30 kV
Windings BIL |
| e. | High Voltage Taps | Two (2) 2-1/2 percent FCAN
Two (2) 2-1/2 percent FCBN |
| f. | Low Voltage (Secondary) | Reference Drawings |
| g. | Low Voltage (BIL) | 10 kV |
| h. | Primary Bus | 30 kA rms
Asymmetrical Amps.
Momentary
Withstand 10 cycles |
5. Nameplate: Temperature rise shall be shown on transformer nameplate along with other pertinent information.
 6. Warranty: Warranty shall include removing, repairing or replacing, transportation, reinstalling and testing without charge to Owner all or any part which shall be found damaged, defective or nonconforming within one year from date of energization, but in no event more than 18 months.

B. Materials and Applications:

1. Insulation System Class: Transformer shall have a limiting temperature of 185 deg. F. (deg. C.) with average winding temperature rise by resistance not exceeding 115 deg. F. (deg. C.) and a hot spot winding temperature rise of 86 deg. F. (30 deg. C.) under all loads in maximum ambient of 104 deg. F. (40 deg. C.). Insulating materials (polyester resin) shall be rated for continuous 428 deg. F. (220 deg. C.) (Class H).
2. Core and Coil Assembly: Core shall be constructed from cold-rolled, high magnetic permeability, grain-oriented, silicon steel laminations. Coils shall be cylindrically constructed using copper conductor material. Coils shall be preheated prior to encapsulation with polyester or epoxy using VPI process.
3. Primary Voltage Taps: Primary voltage taps shall be brazed to high-voltage coils and shall be changed by moving bolted links from one connecting point to another. Taps shall be convenient, accessible, and clearly identified. Taps shall have two (2) 2-1/2 percent (FCAN) and two (2) 2-1/2 percent (FCBN) full-capacity ratings.
4. Fan Controls: High accuracy thermocouples or thermistors shall be placed in each secondary phase winding to activate FA fans and alarm. Transformers shall have (FA) forced air fans within same enclosure. Sound level after adding fans shall not exceed average of 67 dB level in accordance with NEMA TR 27. For fan power a control power transformer with primary and secondary fuse protection shall be provided in low voltage distribution section when secondary voltage is above 240 volts. Transformer fans shall increase transformer capacity by 33 percent.
5. Enclosure: Enclosure shall be constructed from 13 gauge steel and shall have removable panels allowing full access to taps and coils. Base shall be adequately braced with structural steel members. Ventilation louvers shall be directed downward and be in accordance with NEMA standards. Finish on enclosure shall consist of primer and two (2) finish coats of ANSI No. 61 light gray.
6. Accessories to be provided:
 - a. Diagram instruction plate.
 - b. Provisions for lifting and jacking and pulling.
 - c. Ground bus 1/4 inch x 2 inch (6.35 mm x 50.8 mm) copper (minimum).
 - d. Intermediate class metal-oxide type surge arresters shall be provided as close to transformer primary windings as possible. Arresters shall have duty cycle rating of 3 kV rms for use on 2400/4160 volt grounded system.
 - e. Hot spot temperature indicator and control contacts for operation of the alarm signal and Class FA forced-air fans.
 - f. Alarm signaling device.
 - g. Dripproof cover.
 - h. Warning sign "DANGER - HIGH VOLTAGE".

- C. Manufacturer: Dry type secondary unit substation transformers (300 thru 2500 kVA) shall be products of one manufacturer. Transformers shall be products of Eaton Corp., General Electric, Siemens, Square-D, or International Transformer Corp. of Montebello, Calif. Transformers shown are based on Eaton Corp.

2.4 ELEVATOR POWER MODULE SWITCH

A. General:

1. Work of this section shall conform to the requirements of the contract documents.
2. Provide elevator power module switch, fuses and accessories as required and specified on contract drawings to distribute electrical power to elevator.
3. Where more than one elevator driving machine is supplied by a single feeder, the overcurrent protection devices shall be selectively coordinated with any other supply side overcurrent protective device; reference NEC.
4. Related Systems:
 - a. Reference Section 266000, ELEVATORS article for elevator requirements.
 - b. Reference FUSES (TO 600 VOLTS) article in this section for fuse requirements.
 - c. Reference Section 267100 - FIRE ALARM SYSTEM for input signal from the fire alarm system on activation and prior to activation of elevator machine room or hoistway sprinkler system. The fire alarm system shall also monitor the control voltage of the tripping device.
5. Codes: Work shall be performed in accordance with the latest edition of applicable standards, codes and laws.
 - a. NFPA 70 620-51 A-B, 620-62, 645-10, and 700-25 (FPN)
 - b. NFPA 72 Article 3-9.4
 - c. Canadian articles Electric Code Part 1 38-034(3)
 - d. ANSI/ASME A17.1 102.2(4)
 - e. BOCA 3006.2.3
6. Standards: Except as modified by governing codes, all equipment shall be manufactured in accordance with UL98, ENCLOSED AND DEAD FRONT SWITCHES and CSA - C22.2 No. 4.
7. Substitutions: Substitutions shall comply with the requirements of PART 1 of this section. A submittal shall contain sufficient information to prove compliance with contract documents. This includes compliance with all pertinent sections of codes and standards as specified above.
8. Submittals: Submit shop drawings and product data under the provisions of PART 1 of this section and the following:
 - a. Product Data: Provide manufacturer's catalog information showing dimensions, configurations and methods of mounting and installation.
 - b. Submit listing of all types, sizes and quantity of fuses which will be installed including the location of each.
 - c. Spare fuses shall be supplied as specified.

B. Materials and Applications:

1. Provide power module switch in a single NEMA 1 enclosure with all necessary relays, control transformer and other components required and as shown on drawings. The power module switch shall be constructed listed, and certified to the "Standards" listed in General paragraph "A" above.
2. The power module switch shall have an ampere rating as shown on the contract drawings, and shall include a horsepower rated fusible switch with shunt trip capabilities and required options. The ampere rating of the switch and fuse shall be based upon elevator manufacturer's motor requirements and utilize Class J fuses sized to 175 percent of FLA of motor. Verify motor horsepower of each elevator with Architect/Engineer prior to ordering.

3. Each switch shall have a separate control compartment and include a 100 VA control power transformer with primary and secondary fuses. The transformer primary voltage rating shall match elevator power requirements and have a 120 volt secondary. It shall also contain a relay (3PDT, 10 amp, 120 volt). The coil of the relay shall be 120 VAC unless otherwise required. The fire alarm system addressable control modules with normally open (NO) dry contacts rated 140 VA inrush at 120 volt shall be provided to energize the relay and activate the shunt trip solenoid upon activation of the sprinkler system in the associated machine room or hoistway. The control circuit for elevator shutdown shall be monitored for presence of operating voltage. Loss of voltage shall cause a supervisory signal to be indicated at the fire alarm system (per NFPA 72-51). Panel manufacturer shall provide interposing relays where necessary to interrupt circuits requiring contact ratings and contact quantity above that provided by the fire alarm addressable control module.
4. The elevator power module shall also contain the following:
 - a. Keyed test switch
 - b. Pilot light (green) - ON
 - c. 1 NO and 1 NC auxiliary contacts for remote monitoring.
 - d. 1 NO and 1 NC contacts set shall be provided for hydraulic elevators with automatic recall.
 - e. Where an additional power source is connected to the load side of the disconnecting means, an auxiliary contact that is positively opened mechanical, not solely dependent on springs, shall be provided to cause the additional power source to be disconnected from its load when the disconnecting means is in the open position; reference NEC.
5. The module shall have been successfully tested to a short circuit rating with Bussmann LOW-PEAK Class J fuses at 200,000 amps RMS symmetrical. Switches shall have shunt trip capabilities at 120 VAC from closure of normally open contacts of remote the fire alarm addressable control module.

- C. Manufacturer: Bussmann Power Module Switch (PS) or approved equal upon substitution approval by Architect/Engineer.

2.5 FUSES (TO 600 VOLTS)

A. General:

1. Fuses shall be by a single manufacturer.
2. Unless otherwise indicated fuses shall be type as specified for overcurrent protection of conductors and equipment. Fuses for motors shall be sized to provide optimal motor branch circuit protection.
3. Fuses shall not be shipped installed in equipment. Fuses at job site shall be stored in a cool, dry area until installed.
4. Minimum Motor Start/Stop Cycles: Motor circuit fuses in the sizes shown are based on 130 to 175 percent of the motor's full load amps. Fuses shall be capable of handling a minimum of 6000 motor start/stop cycles without fuse element failure due to metal fatigue.
5. IEC and NEMA Style Motor Starters Provided by Other Contractors: When providing fuses for equipment using IEC or NEMA style motor starters or controllers, the Contractor shall provide UL listed fuses that give Type 2 coordination between current limiting fuse and the withstand rating of both the overload relay and contactor. "No Damage" is allowed to either the overload relay or contactor.
6. Substitution:
 - a. Contractor's proposal shall be based upon the fuse specified using the manufacturer's catalog numbers as called for in this section of specifications or on the drawings. Coordination and current limitation for protection of each part of the electrical system has been designed around the type, class and manufacturer specified.

- b. Different manufacturer's fuses of the same UL classification can have different electrical performance and/or electrical characteristics. Therefore, in the event the Contractor wishes to furnish fuses other than those shown on the drawings, a written request, along with a complete short circuit study, selective coordination study and comprehensive current-limitation/component protection study shall be submitted to the Architect/Engineer for evaluation at least 2 weeks prior to bid date. Also included shall be any necessary changes in wire, conduit, fuse and/or switch sizes. If the Architect/Engineer's evaluation indicates acceptance, a written addendum will be issued listing the other acceptable manufacturer.

B. Materials and Applications:

1. Fuses shall have minimum of 200,000 ampere rms symmetrical interrupting rating and be UL listed.
2. Control Circuit Transformers (0.25 to 7.5 Amps): Provide UL Class CC., time-delay Bussmann CC-Tron Type FNQ-R or Littelfuse SLO-BLO Type KLDR or Mersen Amp-Trap ATQR.
3. All Feeder and Motor Circuits (0 to 600 Amps): Provide UL Class J, dual-element, time delay Bussmann, Low-Peak, (System 300 Yellow) LPJ (600V); Mersen, Amp-Trap (System 2000 Orange) AJT (600V); Littelfuse, Powr-Pro JTD-ID (600V).
4. Feeder Circuits (601 to 6000 Amps): Provide UL Class L, time delay, current limiting, bolted-on Bussmann, Low Peak (System 300 Yellow) KRP-C (600 V); Mersen, Amp-Trap, (System 2000 Orange) A4BQ (600 V); Littelfuse, Powr-Pro KLPC (600V).
5. Service Entrance Parallel Feeders 4/0-750 kcmil: Provide short circuit protection on both ends of each cable where three or more cables per phase are indicated. Bussmann Cable Limiter 600V KD Series (tube-to-offset bolt); Littelfuse Cable Limiter 600V LFCL (cable to offset bus).
6. Fuse Cabinet and Spare Fuses: Provide spare fuse cabinets with minimum of two (2) shelves and one set of fuses consisting of a minimum of three (3) fuses for each size fuse (70 amps and larger) used at the switchboards, motor control centers, motor control panels, power panels, and distribution panels. Provide one carton or box of ten (10) fuses for each size fuse smaller than 70 amps in the bottom of each spare fuse cabinet, installed on the project.
7. Combination Switch and Fuse Holder for 120 Volt Motors to 1/2 Horsepower: Provide Bussmann Fusestat Type S dual-element plug fuses, sized for motor running overload protection. Fuses are available in sizes from 0.3 to 14 amps.

- C. Manufacturer: Manufacturer shall be Bussmann, Mersen, or Littelfuse, Inc. The fuse sizes shown on the drawings are based on Bussmann by Eaton Corp.

2.6 LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS

A. General:

1. This article describes low-voltage, dead front, freestanding, switchboards utilizing insulated case draw-out main and group mounted molded case circuit breakers used as main and feeder overcurrent protection devices. The bus ampacity shall be as shown on the drawings.
2. Standards:
 - a. Switchboard(s) shall be front accessible type and shall be engineered and fabricated in accordance with latest revised NEMA PB-2 and UL 891 standards.
 - b. Molded case circuit breakers shall be tested to meet UL 489.
 - c. Circuit Breaker Voltage Markings: Circuit breakers with slant or slash ratings 120/240, 480/277, etc., shall only be installed on systems where voltage to ground does not exceed the lower value in accordance with NEC.
 - d. Switchboard circuit breakers shall be fully rated. Series rated type are not acceptable.

3. Seismic Requirements: Provide appropriate mounting holes for seismic anchors. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for vibration and seismic control requirements.
 4. Submittals: The following minimum information shall be submitted to the Architect/Engineer for approval prior to shipment.
 - a. Master submittal index
 - b. Front view elevation or outline drawing and weight
 - c. Floor plan with recommended pad dimensions
 - d. Schematic diagrams
 - e. Nameplate details
 - f. Component list including circuit breakers and metering types and details
 - g. Conduit entry/exit locations
 - h. Assembly ratings including:
 - 1) Short circuit rating
 - 2) Voltage
 - 3) Continuous current rating
 - i. Major component ratings including:
 - 1) Voltage
 - 2) Continuous current rating
 - 3) Interrupting ratings
 - j. Cable terminal sizes
 - k. When requested the following product information shall also be submitted:
 - 1) Descriptive bulletins
 - 2) Product Data sheets
 5. Delivery, Storage and Handling: Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.
 6. Setting of Circuit Breakers: Contractor shall be responsible for the erection, installation, startup, and testing of equipment covered by this specification article. Circuit breakers shall be set in the field by the switchgear manufacturer's field engineer retained by Contractor. Settings shall be in accordance with recommendations of the Short Circuit and Protective Device Studies article in Section 260100.
- B. Materials and Applications:
1. Structure:
 - a. Switchboard assembly shall be suitable for 600 volts maximum AC service. Switchboard shall consist of a completely enclosed self-supporting metal structure of the required number of formed and welded vertical panel sections incorporating circuit breaker distribution branches and other associated equipment.
 - b. Switchboard circuit breakers shall be fully rated.
 - c. Molded Case CB Provisions: Each individual main and feeder circuit breaker shall be front accessible.
 2. Installation Provisions: Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to floor without use of floor sills.
 3. Hardware: Individual shipping sections shall be designed for bolting together at installation site. Necessary bolting hardware as well as main bus splices shall be supplied between adjacent shipping sections.
 4. Covers: Screwed-on front covers shall be fabricated from 12 gauge sheet steel. Top, side and rear enclosing sheet steel plated shall be removable and shall not be less than 12 gauge. Structure shall be provided with openings for proper ventilation.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

5. Finish: Exterior and interior steel surfaces of the switchboard shall be properly cleaned and finished with ANSI 61 air-dried gray enamel over rust-inhibiting primer.
6. Bus Design:
 - a. Bussing shall be copper with voltage and current ratings as indicated. Bussing shall be fully rated its entire length.
 - b. Bolted joints shall be tin-plated at shipping breaks and provisions for bus extension. Bus supports shall be of a high-shock, non-tracking, non-carbonizing and moisture resistant molded phenolic.
 - c. Auxiliary bussing of rating indicated shall be provided for each "spare", "space" or "blank" by the Contractor. Ampacity of bussing not indicated on the drawings shall be coordinated with Architect/Engineer during the bidding period.
 - d. Bus bracing shall be a minimum of 65,000 rms symmetrical amperes and shall match or exceed short circuit interrupting rating of the highest rated circuit breakers.
 - e. Horizontal bus, whether one above another or in echelon formation, shall be completely insulated from each other and grounded dead metal through use of insulating material.
 - f. Vertical bus shall extend full length of each section.
 - g. Provisions for "future" main bus extension shall be provided in the last feeder section in each switchboard lineup.
7. Ground Bus: Copper ground bus equal to not less than 25 percent of main bus ampacity shall extend full-length of switchboard. Following items shall be connected to the ground bus:
 - a. Grounding conductor run with incoming feeder.
 - b. Each bay of switchboard framework.
 - c. Grounding conductors run with distribution feeders.
 - d. Bonding of the welded wire fabric in the concrete housekeeping pad.
8. Molded Case Circuit Breakers:
 - a. General:
 - 1) Molded case protective devices shall be 100 percent rated solid-state type circuit breakers.
 - 2) The ampere rating shall be determined by the interchangeable rating plug. Breakers shall be 225, 400, 800 amperes frames for Type "ME" breakers and 1200, 1600, 2000 amperes for Type "PE" breakers with 225, 400, 800, 1200, 1600, 2000 ampere sensors with appropriate 100 through 2000 ampere rating plug.
 - 3) Circuit breaker lugs shall be rated for 167 deg. F.
 - b. Construction: Breakers shall provide circuit overcurrent protection by opening the breaker on sustained overload or short circuit conditions. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism. Automatic tripping of the breaker shall be clearly indicated by the breaker handle position.
 - c. Molded case breakers shall have minimum 65,000 amps symmetrical rms interrupting capacity at 480 volts.
 - d. Main and Feeder Circuit Breakers shall have rating plug. Breakers shall be stationary or fixed type with Square-D's "Micrologic" trip system having the following characteristics with x = plug rating in amps, c = current setting, h = short-time rating, and s = sensor amp rating:
 - 1) 225, 400 and 800 Frame:
 - a) Adjustable long-time current setting (0.5x to 1.0x)
 - b) Adjustable longtime pickup (fixed at 1.15c) and delay (1 to 8 bands).

- c) Adjustable short-time pickup (22x to 9x) and delay (4 bands) without I^2T or (4 bands) with I^2T .
 - d) Adjustable instantaneous pickup (2x to 10x).
 - e) High instantaneous pickup setting without adjustable instantaneous pickup option.
 - f) Adjustable ground fault pickup (0.2s to 0.75s) without I^2T or with I^2T .
- 2) 1200, 1600, 2000, and 2500 Amp Frames:
 - a) Adjustable long-time current setting (0.5x to 1.0x)
 - b) Adjustable long-time pickup (fixed at 1.1c) and delay (1 to 8 bands).
 - c) Adjustable short-time pickup (1200 and 1600 amp = 2x to 8x), (2000 amp 2x to 6x) and (2500 amp 2x to 5x) all with (4 bands) without I^2T .
 - d) Adjustable instantaneous pickup (1200 and 1600 amp = (2x to 9x), (2000 amp = 2x to 7x) and (2500 amp 2x to 5.5x).
 - e) High instantaneous pickup setting without adjustable instantaneous pickup option.
 - f) Adjustable ground fault pickup (1200 and 1600 amp = 0.2s to 0.75s), (2000 amp = 0.2s to 65s) and (5000 amp = 0.2s to 0.4s) without I^2T or with I^2T .
- 9. Wiring: Wires and cables shall be identified with a distinct number affixed at terminating ends of each wire and on the terminal strips. These numbers shall be as shown on schematic diagrams. Submit type of marker with shop drawings for approval. Control wiring shall be stranded copper with SIS insulation and not smaller than #14 AWG.
- 10. Nameplates: Provide laminated nameplates with appropriate designations for each circuit breaker, instrument and instrument switch. Nameplates shall be provided in accordance with Section 261950 - ELECTRICAL IDENTIFICATION.
- C. Manufacturer: Circuit breaker switchboards and components shall be the products of General Electric, Eaton Corp., Siemens, Square-D, or approved equal. Layout on drawing is based on Eaton Corp. equipment.

2.7 LOW-VOLTAGE DRY TYPE TRANSFORMERS (500 KVA AND BELOW)

- A. General: This article describes loose-mounted dry type distribution or general purpose transformers with primary of less than 600 volts as indicated and specified.
 - 1. Standards: Transformers shall be built in accordance with latest revised IEEE, ANSI and NEMA Standards. Transformers shall be UL listed and have applicable label.
 - 2. Ventilated transformers shall have internal vibration dampening system consisting of neoprene pads to isolate core and coil assembly from enclosure to provide reduction of 120 Hertz sound and multiple harmonics.
 - 3. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for vibration and seismic control requirements.
 - 4. Nameplate: Temperature rise shall be shown on transformer nameplate along with other pertinent information.
 - 5. Warranty: Warranty shall include removing, repairing or replacing, transportation, reinstalling and testing without charge to Owner all or any part which shall be found damaged, defective or nonconforming within one year from date of energization, but in no event more than 18 months.
 - 6. Submittals: The following information shall be submitted to the Architect/Engineer for approval prior to shipment for each transformer.
 - a. Dimension drawing and weight
 - b. Technical certification sheet
 - c. Conduit entry/exit locations
 - d. Transformer ratings including:
 - 1) kVA
 - 2) Primary and secondary voltage

- 3) Primary taps
- 4) Primary and secondary continuous current
- 5) Basic Impulse level for equipment over 600 volts
- 6) Impedance
- 7) Insulation class and temperature rise
- 8) Sound level

e. When requested the following product information shall also be submitted:

- 1) Descriptive bulletins
- 2) Product data sheets

B. Material and Application:

1. Three Phase Ventilated Distribution Transformers:

- a. Transformers 30 kVA through 500 kVA shall have 60 Hertz, 480 volt (delta) primary and 120/208 volt (wye) secondary with four (4) 2-1/2 percent FCBN taps and two (2) 2-1/2 percent FCAN taps on primary windings.
- b. Transformers 30 kVA through 500 kVA shall have limiting temperature of (185 deg. C.) with average winding temperature rise by resistance not exceeding (115 deg. C.) and hot spot winding temperature rise of (30 deg. C.) under full load in maximum ambient of (40 deg. C.). Insulating materials shall be deg. F. (220 deg. C.) (Class H). Transformers shall be capable of carrying a 15 percent continuous overload.
- c. Transformers 30 kVA through 500 kVA shall have sound levels not exceeding 45 dB for sizes 30 kVA to 45 kVA, 50 dB for sizes 75 kVA to 150 kVA, 55 dB for sizes 200 kVA to 300 kVA and 60 dB for 500 kVA.

C. Manufacturer:

1. Dry type transformers (500 kVA and below) shall be products of one manufacturer where possible. Transformers shall be by Eaton Corp., General Electric, Siemens, Square-D, Jefferson, or ACME Electric Corp. Transformers shown on drawings are based on Eaton Corp.
2. Isolation transformers are based on Emergency Power Engineering Inc. (EPE). Equivalent transformers shall be Square-D (Topaz).
3. Dry type K-Factor transformers for non-sinusoidal loads shall be General Electric (K-Factor), International Transformer Corp., Square-D (Type NL) or Magnetek (Jefferson Plus).

2.8 PANELBOARDS (CIRCUIT BREAKER AND FUSIBLE SWITCH)

A. General:

1. This article covers construction of lighting and appliance branch circuit panelboards and power panelboards.
2. Refer to Panelboard Schedule and one-line power diagram on drawings for specific requirements of each panelboard.
3. Codes and Standards:
 - a. Panelboards shall be furnished and installed to meet NEC. Panelboards and cabinets shall be UL listed and tested to latest revised UL Standard 67 and 50. Panelboards shall be manufactured in accordance with latest revised NEMA standards.
 - b. Panelboards shall be of the dead-front type and shall be in accordance with UL, Standard for Panelboards and Standard for Cabinets and Boxes and shall be so labeled. Panelboard circuit breakers shall be labeled for 167 deg. F. terminations.
 - c. Fully Rated: Short circuit rating of any circuit breaker must match or exceed the available short circuit current. Series rated breakers are not acceptable.
 - d. Seismic Requirements: Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for vibration and seismic control requirements.

4. Service panelboard US-1 shall have "SERVICE EQUIPMENT" label.

B. Materials and Applications:

1. Gutter Space: Lighting and appliance panelboards shall have gutter space top, bottom and sides to meet UL requirements. Panels requiring gutter taps or subfeed lugs shall have extra wide gutters. Gutters shall accommodate the connectors specified in General Power Distribution Requirements article of this section.
2. Doors, Keys and Locks: Each lighting and appliance panelboard shall have front trims with hinged doors and locks unless otherwise indicated. Power distribution panelboards in corridors or other locations accessible to other than maintenance personnel shall have doors with locks. Doors shall have catches and locks with keys. Locks shall be keyed alike.
3. Door-Mounted Directory: When panelboards have doors, directory holder mounted inside of door shall be standard size with protective Lexan or clear plastic cover.
4. Indoor-Mounted Panels: Panelboard enclosures mounted inside the building shall be NEMA 1 and be fabricated with galvanized steel. Trims shall have the same ANSI gray enamel finish except where panels are mounted in finished rooms or corridors. Panelboards that are mounted in finished rooms and corridors shall have trims cleaned and painted in finish selected by Architect/Engineer. Reference Panelboard Installation article for additional details prior to ordering panelboards. Hardware holding trim to enclosure shall be concealed on panelboards in finished rooms or corridors. Trim shall have angle support along the inside bottom serving as support between trim and enclosure for safe installation and removal. Power distribution panelboards in unfinished areas shall have screwed-on trims. Both sections of two-section recessed panelboards shall be of the same height.
5. Assembly and Accessories:
 - a. Assembly: Panelboard interiors shall be factory-assembled complete with branch circuit devices as shown or scheduled. Main busing and enclosures of distribution and power panelboards shall be of such design that branch circuit protective devices may be changed without additional machining, drilling or tapping.
 - b. Phase Busing: Main busing shall be rectangular copper predrilled and tapped to exact pole centers. Main bus shall extend full vertical length of enclosure to allow for future installation of branch circuit devices in spaces or blanks.
 - c. Neutral Bus: Neutral bus shall be provided on 120/240 volt, 120/208 volt and 277/480 volt panelboards. Neutral bus shall be insulated from panelboard backcan, be copper and have an individual terminal for each grounded (neutral) conductor required in a branch circuit or feeder. Panelboards indicated for non-linear loads shall have UL listed 200 percent rated neutral bus.
 - d. Isolation Bus: Isolation bus where called for, shall be insulated from panelboard backcan, be copper and have suitable terminals for each outgoing branch circuit or feeder requiring an isolated ground conductor.
 - e. Equipment Ground Bus: Equipment grounding bus shall be provided where branch circuits and/or feeders to panelboards are indicated to have equipment grounding conductors. Equipment ground bus shall be grounded to panelboard backcan, be copper and have suitable terminals for each outgoing branch circuit or feeder requiring an equipment grounding conductor.
 - f. Accessories:
 - 1) Furnish and install mounted panelboard accessories, such as Main Circuit Breaker (MCB), Double Lugs (DL), Main Contactor (MC), etc., where called for in PANELBOARD SCHEDULE.
 - 2) Padlocking Device: Provide a single pole circuit breaker handle-padlocking device for each circuit breaker feeding "Fire Alarm" branch circuits. Also provide padlocking device on any panelboard ELCI circuit breaker feeding pipe freeze protection and hot water maintenance system branch circuits.

- 3) Oversized Lugs: Provide oversized lugs where required on main and neutral busses to terminate large cables oversized for voltage drop. Reference drawings for cable sizes.
6. Panelboards (Circuit Breaker Type):
- a. Circuit Breakers:
 - 1) Circuit breakers shall be individual unit construction complete with quick-make, quick-break mechanism, and thermal-magnetic trip and be of the indicating type, providing ON, OFF and TRIPPED positions of the operating handle.
 - 2) Multi-pole breakers shall consist of single molded case and be so designed that overload on one-pole automatically causes all poles to open. Handle ties are only acceptable if circuit breakers have internal common trip mechanism.
 - 3) Circuit breakers, unless otherwise noted, shall have min. 167 deg. F. lugs. Continuous ampere rating shall be in 104 deg. F. ambient.
 - 4) Circuit breakers shall be bolt-on type for positive contact with the bus bars.
 - 5) Main and branch circuit breakers shall be sized as indicated.
 - 6) Amp interrupting capacity for 60 Hertz circuit breakers shall be minimum of 10,000 AIC for 240 VAC or 14,000 AIC for 480 VAC unless otherwise indicated.
 - 7) Molded case circuit breakers shall meet latest revised UL 489 standard and be UL listed for installation in panelboard in which they are installed.
 - b. GFCI Personnel Protector (5 milliamp) Circuit Breakers: Breakers 120 or 240 volt one or two-pole - 15, 20, 25 or 30 amp shall be Type QBGF (5 milliamp) with push-to-test button and meet UL 943.
 - c. ELCI or Equipment Leakage Current Interrupter (30 milliamp): Provide one of the following as required.
 - 1) ELCI Circuit Breakers 120 Volt Single-Pole and 240 Volt, Two-Pole: 15, 20, 25 or 30 amp shall be Type QO-EPD with push-to-test button. Ground fault circuit interrupters shall meet the latest revised UL 943 standard.
 - 2) Circuit Breakers 240 Volt, Two-Pole: 15, 20, 25, or 30 amp shall be Type QO-EPD with push-to-test button. Ground fault circuit interrupters shall meet the latest revised UL 943 standard.
 - 3) ELCI Circuit Breakers 277 Volt, Single-Pole: 15, 20, 25, or 30 amp shall be Type GHBGFEF with push-to-test button. Ground fault circuit interrupters shall meet the latest revised UL 943 standard.
 - 4) "E" Frame Circuit Breaker with Ground Fault Sensing Relay 120 or 240 Volt, One, Two or Three-Pole: 15 through 100 amp E frame circuit breaker.
 - d. Circuit breakers in 100 amp frame size with trips 40 amps and above shall have terminals rated for 167 deg. F.
 - e. Circuit breakers in 110 amp through 225 amp frame sizes shall be thermal-magnetic trip with inverse time current characteristics, unless otherwise noted.
 - f. Circuit breakers in 400 amp, 600 amp, 800 amp and 1200 amp frame sizes shall have interchangeable trips and have adjustable instantaneous magnetic trip (low-high). Continuous current trip ratings of breakers shall be as indicated. Adjustments to trips shall not be readily accessible.
 - g. Current Limiting Molded Case Circuit Breakers:
 - 1) Breakers must meet UL 489 and have 200,000 AIC.
 - 2) Current-limiting breakers shall not incorporate a fusible element and shall when operating within its current limiting range limit the let-through IT to a value less than the IT of a 1/2 cycle wave of the available symmetrical short circuit current.

- 3) Breakers shall have a minimum interrupting rating of 100,000 amps rms symmetrical at 240 volts or 480 volts.
 - 4) 100 amp frame breakers shall have fixed thermal-magnetic trips. 225 amp and 400 amp frame breakers shall have fixed thermal trip and adjustable magnetic trip elements.
 - 5) Accessories such as shunt-trip, undervoltage trip and auxiliary contacts shall be provided as indicated.
- h. HACR Type Circuit Breakers: Where HACR type circuit breakers (250 VAC or less, 60 amp maximum) are required by heating, air conditioning and refrigeration equipment manufacturers for appropriate level of protection of circuit components, Contractor shall provide UL 489 HACR type circuit breakers.

C. Manufacturer:

1. Panelboards shall be products of one manufacturer unless otherwise noted and shall be standard products of Eaton Corp., Square-D, General Electric, or Siemens.
2. Equipment shown on drawings and in specifications is based on standard products of Eaton Corp. Contractor shall be responsible for space requirements of other approved manufacturers.

2.9 SECONDARY UNIT SUBSTATIONS

A. General:

1. Furnish and install where indicated, close-coupled, coordinated, power center, including medium voltage incoming 5 kV switch section,. Unit substation includes as a unit the transformer section, secondary main, transition and low voltage distribution sections. Switching and protective devices shall be provided in rating and type specified or indicated. Unit substation(s) shall have necessary interconnections, instrumentation and control wiring.
2. Construction: Unit substation(s) shall be of indoor dead-front type, completely metal enclosed in a freestanding structure.
 - a. Structure: Structure shall be of universal frame type using die-formed, welded or bolted members. Sides, top and rear enclosure covers shall be bolted on. Enclosing covers shall be fabricated from not less than 11 gauge steel. Structures shall be provided with adequate lifting means and shall be capable of being rolled and moved into position and bolted to the concrete housekeeping pad.
 - b. Finish: Enclosing and supporting steel shall be thoroughly cleaned to assure proper surface for prime and finish coats. Final coat shall be fast-drying enamel and shall be ANSI-61 light gray for indoor units. Finish paint shall be of a type to which field-applied paint will adhere.
 - c. Air-Interrupter Switch Interface at Transformer: Transition section with steel barrier shall be provided between primary switch cubicle and transformer. Transition section between incoming switch and transformers shall have removable cover. Cover when removed shall allow transformer high-voltage bushing to clear transition section upon removal of transformer straight out front aisle without removing high-voltage switch.
3. Signs and Nameplates: Warning signs reading "DANGER - HIGH VOLTAGE - KEEP OUT" shall be provided at end on each 5 kV switch section and at doors entering room where substation is located.
4. Shop Drawings: Shop drawings shall be furnished providing following minimum information:
 - a. Front and plan view of the assembly with overall outline dimensions for both views including NEC code required working space for 5 kV primary switchgear, transformer, 600 volt secondary switchgear and 600 volt switchboard.
 - b. Bill of material or component list.
 - c. Schematics on controls, meters and alarms.

- d. Assembly short circuit, voltage and continuous current ratings.
 - e. Major component voltages continuous current and interrupting ratings.
 - f. Switch ratings 5 kV and 600 volts including ground fault, undervoltage and single phase protection.
 - g. Fuse details and ratings 5 kV and 600 volts.
 - h. Transformer sound levels and all electrical ratings.
 - i. Standard factory test data.
 - j. One-line diagram.
- 5. Standards: Unit substations shall conform to applicable NEMA and ANSI standards.
 - 6. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL article for vibration and seismic control requirements of floor mounted equipment.
 - 7. Prototype Factory Test Data: Certified copies of factory design test report of 60 kV impulse and 19 kV withstand for 60 Hertz one minute tests, rated continuous current tests, momentary current tests and interrupting tests on the switchgear assembly shall be submitted with shop drawings.
- B. Materials and Applications:
- 1. Incoming Air-Interrupter 5 kV Switch Section:
 - a. Two-Position Switch Type: Incoming fusible switch(es) shall be manual load-break, 3-pole, single throw, quick-make, quick-break, stored energy type. Switch shall be mounted in dead front, completely metal-enclosed freestanding switchgear structure.
 - b. Lugs: Line-side of incoming switch shall be equipped with correct size and quantity of compression type lugs for 5 kV service cables. Refer to Section 261100, Conductors above 600 Volts (EPR) article for type of cable termination kits to be used.
 - c. Interface Conductors: Bus lugs on the load side of switch shall be equipped with adequately braced unshielded 15 kV cable wired bolted busing run to metal oxide gapless type surge arresters located on transformer primary.
 - d. Ratings of Metal Enclosed Assembly:
 - 1) Maximum Design Voltage: 5 kV
 - 2) System Voltage: 4.2 kV
 - 3) Momentary Current: 40 kA sym.
 - 4) Main Copper Bus Rating: 600 amps
 - e. Ratings of Air Interrupter Switch:
 - 1) Nominal Voltage: 4.2 kV
 - 2) Basic Impulse Level (BIL): 60 kV
 - 3) Continuous Current and Load Current Interrupting: 600 amps
 - 4) Momentary Switch Closed (10 cycle): 40 kA asym.
 - 5) Fault Close: 40 kA asym.
 - f. Switch (Manual) Operator:
 - 1) Load interrupter switches shall be stored energy operation type.
 - 2) Quick-make, quick-break manual operating mechanism shall be provided utilizing heavy-duty coil spring for powerful opening and closing action of switch. To assure reliable operation, spring charging mechanism shall consist of rigid metal-to-metal linkage.
 - 3) Speed of opening and closing of switch shall be independent of operator. With handle inserted in spring charging cam, switch shall be closed by upward movement to charge the compression spring. At predetermined point in charging cycle, mechanism shall go over toggle, releasing the stored energy of spring to switch, snapping the switch closed. It shall be impossible to tease switch into any intermediate position. Switch opening

- shall be accomplished by a downward motion of handle resulting in compression of spring and releasing its stored energy in a similar sequence.
- 4) Operating mechanism shall be designed to provide sufficient power to overcome blowout forces when closing switch into a fault.
- g. Switch Contacts:
 - 1) Main and Arcing Contacts: Interrupter switch shall have separate main make and break contacts to provide maximum endurance for fault close and load interrupting duty. Arcing contacts shall be spring-loaded on make and break and shall be so designed as to be last in and last out. Arc interruption shall take place within urea formaldehyde arc chutes, which produce a high dielectric gas to assist interruption.
 - 2) Auxiliary Contacts: Each switch shall have auxiliary contacts wired to a terminal block on top of switch cubicle for remote indication of both "open," "closed" or "feeder selection" positions of unit substation switch(es). Conduit shall be metallic and be bonded to the metal enclosed structure. Contact wiring from terminal block shall be wired to Building Automation System (BAS) for remote status indication.
 - h. Doors:
 - 1) Front door shall be mechanically interlocked to prevent opening of door unless switch is open and to prevent closing switch unless door is closed.
 - 2) Front door shall be single, full-length, flanged type door and have high-impact viewing window to observe position of switchblades.
 - 3) Front door shall have provisions for padlocking and permanent open-closed switch position indicators.
 - i. Main Bus Design:
 - 1) Main bus shall consist of silver-plated copper bus bar at bolted joints. Bus shall be mounted on NEMA rated insulators for voltage class and BIL specified.
 - 2) Design of buses, connections and supports shall be consistent with mechanical stresses produced by short circuit current equivalent to interrupting current rating of associated switch and fuse at indicated service voltage.
 - j. Ground Bus: Copper ground bus equal to minimum of 25 percent of main bus ampacity shall be firmly secured to each vertical section and shall extend the entire length of switch sections. Following items shall be connected to ground bus:
 - 1) Shield ground straps from termination stress cones.
 - 2) Each bay of switchgear's framework.
 - 3) Any grounding conductors run with service or distribution feeders.
 - k. Finish shall consist of coat of baked polyester enamel light gray ANSI 61 applied to hot phosphatized treated steel for internal and external parts. Prior to shipment, completed assemblies shall be given exterior finish coat of air-drying enamel ANSI 61 for indoor equipment.
2. Transformer Sections:
 - a. Refer to Dry Type Secondary Unit Substation Transformers (300 kVA to 2500 kVA) article in this section of specifications, for detailed requirements.
 - b. Primary switch, transformer and secondary main switchgear and switchboard distribution sections shall be in neat and professional alignment.
 3. Low Voltage Distribution Sections:
 - a. Refer to Unit Substations Low-Voltage (Circuit Breaker) Switchboards article, this section of specifications for detailed requirements.

- b. Transition section shall be provided between transformer and secondary switchgear and switchboard.
 - C. Manufacturer/Supplier: Secondary unit substations shall be manufactured/supplied by General Electric, Square-D, Eaton Corp., or Siemens. Drawings are based on Eaton Corp.
- 2.10 UNIT SUBSTATION LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS
- A. General: This article describes unit substation low voltage, dead front, freestanding, switchboard sections utilizing main circuit breakers and group mounted feeder circuit breakers. Main circuit breakers shall be 100 percent rated draw-out type with adjustable solid-state trips. Feeder circuit breakers shall be fixed molded-case type.
 - 1. Standards:
 - a. Switchboard(s) shall be rear accessible and shall be engineered and fabricated in accordance with latest revised NEMA PB-2 and UL 891 standards.
 - b. Molded case circuit breakers shall be tested to meet UL 489.
 - c. Circuit Breaker Voltage Markings: Circuit breakers with slant or slash ratings 120/240, 480/277, etc., shall only be installed on systems where voltage to ground does not exceed the lower value in accordance with NEC.
 - d. Circuit breakers shall be fully rated. Series rated type are not acceptable.
 - 2. Seismic Requirements: Provide appropriate mounting holes for seismic anchors. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL article for vibration and seismic control requirements.
 - 3. Submittals: The following minimum information shall be submitted to the Architect/Engineer for approval prior to shipment.
 - a. Master submittal index
 - b. Front view elevation or outline drawing and weight
 - c. Floor plan with recommended pad dimensions
 - d. Schematic diagrams
 - e. Nameplate details
 - f. Component list including circuit breakers and metering types and details
 - g. Conduit entry/exit locations
 - h. Assembly ratings including:
 - 1) Short circuit rating
 - 2) Voltage
 - 3) Continuous current rating
 - i. Major component ratings including:
 - 1) Voltage
 - 2) Continuous current rating
 - 3) Interrupting ratings
 - j. Cable terminal sizes
 - k. Where applicable the following information shall also be submitted:
 - 1) SPD
 - 4. Delivery, Storage and Handling: Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.
 - 5. Setting of Circuit Breakers: Contractor shall be responsible for the erection, installation, startup, and testing of equipment covered by this specification article. Circuit breakers shall be set in the field by the switchgear manufacturer's field engineer retained by Contractor. Circuit breakers settings or adjustments shall be provided by Contractor in accordance with Architect/Engineer's instruction. Settings shall be in accordance with recommendations of the Short Circuit and Protective Device Studies article in Section 260100.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

B. Materials and Applications:

1. Structure:
 - a. Switchboard assembly shall be suitable for 600 volts maximum AC service.
 - b. Fixed and Molded Case CB Provisions: Each individual main and feeder circuit breaker shall be rear accessible.
 - c. Circuit breakers lugs shall be rated for minimum 167 deg. F.
2. Installation Provisions: Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to floor without use of floor sills.
3. Hardware: Individual shipping sections shall be designed for bolting together at installation site. Necessary bolting hardware as well as main bus splices shall be supplied between adjacent shipping sections.
4. Covers: Screwed-on front covers shall be fabricated from 12 gauge sheet steel. Top, side and rear enclosing sheet steel plate shall be removable and shall not be less than 12 gauge. Structure shall be provided with openings for proper ventilation.
5. Finish: Exterior and interior steel surfaces of switchboard shall be properly cleaned and finished with ANSI 61 gray enamel over rust-inhibiting primer.
6. Bus Design:
 - a. Bussing shall be copper with voltage and current ratings indicated. Bussing shall be fully rated and insulated its entire length. Bolted joints shall be silver-plated at shipping breaks and provisions for bus extension. Bus supports shall be of high-shock, non-tracking, non-carbonizing and moisture resistant involved phenolic.
 - b. Bussing for each circuit breaker shall include auxiliary 3 phase bus of correct ampacity between section bus and breaker line-side studs. Load-studs shall be equipped with load extension busses terminating in solderless type terminals in rear cable compartment of each section.
 - c. Auxiliary bussing of ratings indicated shall be insulated and be provided for each "spare," "space" or "blank". Ampacity of bussing not indicated on the drawings shall be coordinated by the Contractor with Architect/Engineer during the bidding period.
 - d. Bus bracing shall be a minimum of 65,000 rms symmetrical amperes and shall match or exceed short circuit interrupting rating of highest rated circuit breaker.
 - e. Horizontal bus, whether one above another or in echelon formation, shall be completely insulated from each other and grounded dead metal through use of insulating material.
 - f. Vertical bus shall extend full length of each section.
 - g. Provisions for future main bus extensions shall be provided in the last feeder section in each switchboard lineup.
7. Ground Bus: Copper ground bus equal to not less than 25 percent of main bus ampacity shall extend full length of switchboard. Following items shall be connected to ground bus:
 - a. Each bay of the switchboard framework.
 - b. Grounding conductors run with distribution feeders.
 - c. Provide a Grounding Electrode System in accordance with NEC and Section 264500 - GROUNDING AND BONDING.
 - d. Provide grounding for a Separately Derived AC system in accordance with NEC and Section 264500 - GROUNDING AND BONDING.
 - e. Bonding of the welded wire fabric in the concrete housekeeping pad.
8. Insulated Case Circuit Breakers (1600 and 1200 Amp):
 - a. General: Protective devices shall be 100 percent rated solid-state type insulated case circuit breakers.
 - b. The ampere rating shall be determined by the interchangeable rating plug. The 1600 amp shall be "Micro Versa Trip PM" type with digital LCD display having

- multi-meter function. The 1200 amp shall be "Micro Versa Trip PLUS" type with digital LCD display ammeter. Circuit breaker lugs shall be rated for 167 deg. F.
- c. Digital Display for 1200 and 1600 amp Frame:
 - 1) Three phase ammeter with + 4 percent accuracy - 1200 and 1600 amp
 - 2) Three phase voltmeter, + 4 percent accuracy - 1200 and 1600 amp only
 - 3) Frequency meter, + 0.5 Hz - 1200 and 1600 amp only
 - 4) kW meter, + 10 percent - 1200 and 1600 amp only
 - 5) kWh meter, + 10 percent - 1200 and 1600 amp only
 - d. Construction: Breakers shall provide circuit overcurrent protection by opening the breaker on sustained overload or short circuit condition. Circuit breakers (Power Break II Type) shall be operated by a precharged spring loaded quick-make, quick-break switching mechanism. Automatic tripping of the breaker shall be clearly indicated by Green (OFF) or Red (ON) indicator window on front of the breakers. Handle on breaker shall provide necessary spring charging by simple rotation. Circuit breakers shall be UL listed.
 - e. 1600 and 1200 amp Circuit Breakers shall have rating plug. Breakers shall be General Electric's "Micro Versa Trip Digital RMS" function solid-state programmer type having the following characteristics with x = plug rating in amps, c = current setting.
 - 1) Adjustable current setting (0.5x to 1.0x) - 1200 and 1600 amp
 - 2) Adjustable long-time pickup (0.5x to 1.0x) and delay (3-4 bands) - 1200 and 1600 amp
 - 3) Adjustable short-time pickup (1.0 to 9.0c) and delay (4 bands) with I²T ON/OFF selection - 1200 and 1600 amp
 - 4) Adjustable instantaneous pickup (1.5x to 10x) without short-time or (1.5x to 15x) with short-time - 1200 and 1600 amp
 - 5) Local overload and short circuit trip indicators - 1200 and 1600 amp
9. Molded Case Circuit Breakers:
- a. General: Molded case protective devices shall be solid-state type circuit breakers.
 - 1) Main: The ampere rating shall be determined by the interchangeable rating plug. Breakers shall be type "SKH" breakers with adjustable electronic trip with long time delay and instantaneous pickup, short time pickup and delay, and ground fault pickup and delay with zone selective interlocking and with push-to-test and digital LCD display multi-metering.
 - 2) Other Breakers: Other breakers shall be (Frame/trip "Type") 100/40 "KC," 100/70 "FC," 100/100 "FC," 200/200 "KC," 400/350 "LC," 1000/1000 "NA" thermal magnetic.
 - 3) Circuit breaker lugs shall be rated for 167 deg. F.
 - b. Construction: Breakers shall provide circuit overcurrent protection by opening the breaker on sustained overload or short circuit conditions. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism. Automatic tripping of the breaker shall be clearly indicated by breaker handle position.
 - c. Molded case breakers shall have minimum 65,000 symmetrical rms interrupting capacity at 480 volts.
 - d. Time Current Curves: Manufacturer shall supply time current curves for each size breaker. Circuit breaker curves shall be on same size of time current graph paper.
 - e. Ground Fault Protection System: Main circuit breaker(s) shall have ground fault protection system either as integral part of main circuit breaker or as addition to it. System shall have total adjustability and testing functions.

10. Customer Metering: Main incoming section of secondary switchboard shall be equipped with:
 - a. +/- 1 percent accuracy 4-1/2 inch square, 250 degrees circular scale, ammeter and voltmeter with current and voltage transformers and phase selector switches (four-position for ammeter and seven-position for voltmeter). Ammeter shall have 100 percent bus rating scale with maximum demand indicator and push/turn reset knob; current transformers and microprocessor based metering equipment also, provide test block with series test (10-pole) plug for measuring amps and voltage on each phase with portable multi-meters.
 11. Wiring: Wires and cables shall be identified with a distinct number affixed at terminating ends of each wire and on terminal strips. These numbers shall be as shown on schematic diagrams. Submit type of marker with shop drawings for approval. Control wiring shall be stranded copper with SIS insulation and not smaller than #14 AWG.
 12. Nameplates: Provide laminated nameplates with appropriate designations listed or as otherwise directed, shall be furnished for each circuit breaker, instrument and instrument switch. Nameplates shall be provided in accordance with Section 261950 - ELECTRICAL IDENTIFICATION.
- C. Manufacturer:
1. Secondary substation circuit breaker switchboard(s) and components shall be the products of Eaton Corp., General Electric, , Square-D, or approved equal. Layout on drawing is based on Eaton Corp. equipment.
 2. Test block at customer metering shall be Eaton Corp., Flexi-Test type, GE No. PK2 or equal.
 3. Reference Microprocessor Based Metering Equipment article for details of metering.

PART 3 - EXECUTION

3.1 AUTOMATIC TRANSFER SWITCH INSTALLATION AND TEST

- A. Transfer switch(es) shall be stored indoors until being installed. Storage area shall be climate controlled between limits of minus 4 deg. F. to 185 deg. F. with relative humidity of 80 percent or less non-condensing.
- B. Transfer switch(es) shall be rigidly mounted at location indicated.
- C. Control and Signal Wiring: Contractor shall furnish, install and wire all remote control and signal circuits in conduit. This includes ATS wiring for remote status on the remote alarm annunciator, and ATS engine start contact wiring to generator controller, and elevator transfer switch signal wiring to elevator controller. Control and signal wiring shall be tinned and identified with wire markers.
- D. Transfer switch(es) shall be protected from accumulation of dust and dirt during construction. Transfer switch(es) interior(s) shall be cleaned by removing all foreign matter and vacuum cleaning.
- E. Transfer switches for fire pump shall meet 1996 NFPA 20, Section 7-8.
- F. Automatic Transfer Switch Startup Test: Contractor and manufacturer's engineer shall perform the following tests on each automatic transfer switch prior to Architect/Engineer's final observation. Contractor shall obtain final time settings from Engineer and make all final adjustment in settings prior to test. Tests shall be recorded and shall include for each and separate from others the following:
 1. Phase rotation of all feeders (normal, emergency and load) shall be tested. Where ATS are connected for selection of two (2) sources fed from separate delta-wye transformers, the ATS shall not parallel the two power sources.
 2. Engine starting by simulated failure of normal power by opening switch or circuit breaker providing normal power to the transfer switch.

3. Engine starting by simulating failure of normal power by operation of ATS mounted Test Switch.
 4. Elapsed time from normal power failure to transfer to generator power upon simulated power failure by paragraphs 2, and 3 and 4.
 5. Simulate restoration of normal power by restoring system's normal power by reverse operation of items in paragraphs 2, and 3 and 4.
 6. Elapsed time from restoration of normal power to transfer to utility power.
 7. Generator load in kW at time of each transfer (load on transfer switch).
- G. Certified Test Report: Contractor shall provide Architect/Engineer with certified test report for each transfer switch, 4 weeks prior to Engineer's final observation indicating that tests have been performed free of malfunctions. Contractor shall also include startup test record data for all transfer switches as certification. Certified test reports shall be provided in accordance with Section 260100, Testing article.

3.2 DISCONNECT SWITCH INSTALLATION

- A. Disconnect switches shall be provided in sight of the motor where the motor is out of sight from controller location and the controller disconnect cannot be locked in the "open" position.
- B. Switches shall be rigidly supported.
- C. Disconnect switches on exterior walls or outdoors shall be mounted on appropriate U-type channel galvanized steel framing members.

3.3 DRY TYPE SECONDARY UNIT SUBSTATION TRANSFORMERS (300 KVA THROUGH 2500 KVA) INSTALLATION AND TESTS

- A. Transformers shall be installed in accordance with manufacturer's instructions and the requirements of this article.
- B. Verify that reinforced concrete housekeeping pad and anchors are correct size and in correct location. Reference Section 260500, CONCRETE WORK article for concrete pad requirements. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for transformer vibration isolators and anchor bolts.
- C. Transformers shall be kept upright and stored in warm dry location. Ventilating openings shall be covered to keep out dust. If transformers are to be kept outdoors, the transformer shall be completely covered to prevent moisture and foreign material from entering.
- D. When a transformer cannot be lifted by a crane, it shall be skidded or moved on rollers, but care must be taken not to damage base or tip it over. When rollers are used under large transformers, skids shall be used to distribute stress over the base.
- E. Jacking lugs, two (2) on each long side of the enclosure base, are provided for raising larger transformers with their enclosures. Transformer should be jacked evenly on four (4) corners to prevent tipping over.
- F. Locate transformers on concrete housekeeping pads in correct location above anchor bolts.
- G. Voltage Adjustment: Check voltages and make necessary adjustments on transformer taps to compensate for any overvoltage or under-voltage condition. Contractor shall make necessary adjustments on transformers installed under his contract as required to achieve correct secondary system voltage at transformer output terminals.
- H. Dry Type Transformer Field Tests: Contractor shall provide certified test reports for following items in accordance with Section 260100, Testing article.
 1. Insulation Resistance Test: Insulation resistance test shall be performed and recorded on transformers prior to energizing transformer or beginning the dielectric test. Test shall be performed as recommended by transformer manufacturer. In absence of any available manufacturer's test, following test shall be used:

- a. Disconnect high voltage, low voltage and neutral connections, as well as lightning arresters, fan system, meters or low voltage control system that is connected to windings involved in this test. Do not disconnect ground connection to transformer frame.
 - b. Before beginning Megger checks, jumper together high voltage connections. Make sure jumpers are clear of steel and grounded parts. Also jumper together all low voltage and neutral connections again making sure jumpers are clear of steel and grounded parts.
 - c. On standard transformers use a Megger with a minimum scale of 2000 megohms and minimum rating of 1000 volts, make Megger checks with Megger connected as follows: (NOTE: Each Megger check to be maintained for a period of one minute.)
 - 1) High voltage to ground
 - 2) Low voltage to ground
 - 3) High voltage to low voltage
 - d. If field-test Megger values are less than 1000 Megohms or less than one-half of factory test readings, the transformer is not considered safe for energizing. Transformer should be dried out as outlined by manufacturer and field test repeated.
 - e. Field test values shall be 1000 megohms or greater. Such transformers are considered safe for energizing. Transformer connections should be remade and transformer energized only after completing dielectric test.
2. Dielectric Test: Dielectric test imposes a stress on the insulation since dielectric test voltage is higher than normal operating voltage.
- a. After insulation test has been successfully completed, perform dielectric test immediately.
 - b. Verify exact testing procedures and voltages with the manufacturer and perform test.
 - c. After transformer has successfully passed dielectric test it shall be immediately energized after removal of testing equipment and proper reconnection of arrestors and control circuits, according to manufacturer's instructions.
3. Verify correctness of phase and tap connections of all windings.
4. Manufacturer of new transformers shall also provide instructions for testing, installing, and drying out transformers.

3.4 ELEVATOR POWER MODULE SWITCH INSTALLATION

- A. Installation shall be in accordance with manufacturer's recommendations and the provisions of applicable codes.
- B. Fuses shall not be installed until equipment is ready to be energized.
- C. Keyed test switch shall be operated to verify operation of shunt trip. Also verify that the green pilot light illuminates on operation of test switch.

3.5 INSTALLATIONS OF FUSES (TO 600 VOLTS)

- A. Fuses shall be of proper voltage class corresponding to electrical distribution system in which used.
- B. Fuses shall not be shipped installed in equipment. Fuses shall be installed prior to energizing equipment.
- C. Cartridge fuses shall be installed with fuse type and rating marked on label totally visible.
- D. Fuses installed in each fusible switch shall be of same size and type.
- E. In general, fuse reducers shall not be used.

3.6 INSTALLATION OF LOW-VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS

- A. Verify that reinforced concrete housekeeping pad and anchors are correct size and in correct location. Reference Section 260500, Concrete Work article for concrete pad requirements. Reference section 262400 - VIBRATION AND SEISMIC CONTROL for anchor bolts.
- B. Lifting or hoisting means shall adequately support the sections. Contractor shall install equipment in accordance with manufacturer's installation instructions.
- C. Locate switchboards above any conduit stubs and allow for cable bending space and clearances to live parts. Switchboards shall not be placed directly against wall but shall have minimum 1 inch air space.
- D. Connect busses together at shipping sections in accordance with manufacturer's torque specifications. Switchboard trim pieces with louvers shall have louvers directed downward.
- E. Circuit breakers or switches shall be OPEN prior to making wiring connections. Install wire and cable taking care as to avoid possibility of future physical damage and overheating of cables. Phase conductors of feeder circuit shall be of same length. Do not exceed wire and cable manufacturer's bending radius at terminations. Ground switchboard cubicles and conduit stubs to ground bus with bonding jumpers.
- F. Cable lugs shall be of correct size and type to match the conductor and be tightened to manufacturer's recommended torque values.
- G. Before energizing the switchboard, contractor shall perform visual inspection and perform 600 volt feeder insulation test as specified in Section 260100, Testing article.
- H. Install fuses of appropriate type, size and voltage.
- I. Operate all switches and circuit breakers three (3) times manually under load. Switches and circuit breakers failing to open and close shall be replaced at Contractor's expense.
- J. Nameplates: Refer to specification Section 261950 - ELECTRICAL IDENTIFICATION for nameplate requirements.
- K. Exposed finished sheet metal front, sides and back shall be cleaned and tape, stickers and other markings shall be removed. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.
- L. Inside of switchboards shall be vacuumed clean just prior to final observation.

3.7 LOW-VOLTAGE DRY TYPE TRANSFORMERS (500 KVA AND BELOW) INSTALLATION AND TESTS

- A. Verify that reinforced concrete housekeeping pad is correct size and in correct location. Reference Section 260500, Concrete Work article for concrete pad requirements. Reference section 262400 - VIBRATION AND SEISMIC CONTROL for vibration isolators and anchor bolts.
- B. Transformers shall be kept upright and stored in a warm dry location. Ventilating openings shall be covered to keep out dust. If transformers are to be kept outdoors, the transformer shall be completely covered to prevent moisture and foreign material from entering.
- C. Transformers indicated to be floor-mounted shall be mounted on concrete housekeeping pads unless otherwise indicated. Transformers shall be located a minimum of 6 inch (152.4 mm) clear of walls and other equipment. When wall or ceiling hung transformers are indicated, Contractor shall provide mounting devices, hardware and vibration isolation.
- D. For transformers hung from the structure, reference Section 261900 - EQUIPMENT SUPPORTING DEVICES for transformer trapeze supports. Reference Section 262400 for supports and seismic sway bracing.
- E. Exposed finished sheet metal front, sides and back shall be cleaned and all tape, stickers, and other marks shall be removed. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final inspection.

- F. Provide grounding of transformer in accordance with NEC.
- G. Voltage Adjustment: Check service entrance voltages and make necessary adjustments on transformer taps to compensate for any overvoltage or undervoltage condition. Contractor shall make necessary adjustments on transformers installed under his contract to achieve correct secondary system voltage at transformer output terminals.
- H. Dry Type Transformer Field Tests: Contractor shall provide certified test reports for following items in accordance with Section 260100, Testing article.
 - 1. Insulation Resistance Test: Insulation resistance test shall be performed and recorded on transformers prior to energizing. Test shall be performed as recommended by transformer manufacturer. In absence of available manufacturer's test, following test shall be used:
 - a. Disconnect all high voltage, low voltage and neutral connections, as well as lightning arresters, fan system, meters or any low-voltage control system that is connected to any windings involved in this test. Do not disconnect ground connection to transformer frame.
 - b. Before beginning Megger checks, jumper together all high voltage connections. Make sure jumpers are clear of all steel and grounded parts. Also jumper together all low voltage and neutral connections, again making sure jumpers are clear of all steel and grounded parts.
 - c. On standard transformers use a Megger with a minimum scale of 2000 megohms and minimum rating of 1000 volts; make Megger checks with the Megger connected as follows: (NOTE: Each Megger check to be maintained for a period of one minute.)
 - 1) High voltage to ground
 - 2) Low voltage to ground
 - 3) High voltage to low voltage
 - d. If field-test Megger values are less than 1000 Megohms or less than one-half of the factory test readings, the transformer is not considered safe for energizing. Transformer should be dried out as outlined by manufacturer and field test repeated.
 - e. Field test values shall be 1000 megohms, or greater. Such transformers are considered safe for energizing. Transformer connections should be remade and transformer energized only after completing dielectric test.
 - 2. Dielectric Test: Dielectric test imposes stress on insulation since dielectric test voltage is higher than normal operating voltage.
 - a. After insulation test has been successfully completed, perform dielectric test immediately.
 - b. Verify exact testing procedures and voltages with manufacturer and perform test.
 - c. After transformer has successfully passed the dielectric test it shall be immediately energized after removal of equipment and proper reconnection of arresters and control circuits, according to the manufacturer's instructions.
 - 3. Verify correctness of phase and tap connections of all windings.
 - 4. Manufacturer of new transformers shall also provide instructions for testing, installing, and drying out transformers.
- I. Where transformers are identified with T-1, T-2 or other similar markings on the drawings, the contractor shall provide engraved nameplates with transformer marking and kVA rating. Reference Section 261950 - ELECTRICAL IDENTIFICATION.
- J. Line and load conductors for single phase, non-ventilated transformers shall be 194 deg. F. (90 deg. C.) insulated type conductors.

3.8 PANELBOARD (CIRCUIT BREAKER AND FUSIBLE SWITCH) INSTALLATION

A. General:

1. Wall-Mounted Panelboards:

- a. In general the tops of wall mounted panelboards surface or recessed shall be mounted approximately 6 ft. above the floor. However, the topmost switch or circuit breaker in a panelboard shall not be higher than 6 ft.-6 inch above floor.
- b. When panelboards are mounted alongside other panel types (i.e. relay panels, control cabinets, or communications system panels) that are flush or recessed mounted, all panel trims shall be aligned at top.

2. Panelboard enclosures shall be mounted permanently and securely in place. Where multiple panelboards are installed, panelboard enclosures shall be positioned to allow panelboard trims to align at the top. Reference following paragraph C. for additional details.

3. Run all conduits to panelboard enclosures to meet job requirements.

4. Correct size of circuit breakers, fusible switches, etc., shall be mounted in place to match branch circuits indicated on the drawings.

5. Run all circuit conductors in conduits and terminate on appropriate overcurrent protective device. Verify that all cable and wire connections are adequately torqued to provide good electrical contact free from overheating.

6. Panelboard interiors shall be cleaned and all foreign matter removed. Decals, stickers, and other markings except panelboard nameplates shall be removed from panelboard exterior. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.

7. Panelboard trims shall meet flush with enclosure or wall without bowing.

B. Floor-Mounted: Floor-mounted panelboards shall be anchored to floor with a minimum of four (4) seismic anchor bolts and vibration isolation bushings.

C. Surface Mounted:

1. Panelboards in unfinished spaces shall be surface mounted.

2. Exterior Walls: Panelboards on building exterior walls shall be mounted on U-type channel framing members to provide minimum 1 inch air space between panel and wall. Refer to Section 261900 - ELECTRICAL EQUIPMENT SUPPORTING DEVICES article for additional requirements.

3. Interior Walls: Panelboards shall be secured to wall at a minimum of four (4) locations using appropriate type seismic anchors and vibration isolators.

D. Recessed Mounted:

1. Panelboards in finished rooms or finished corridors shall be recessed.

2. Spare Conduits: Panelboards shall have spare conduits stubbed above ceiling. Not less than four (4) 3/4 inch or two (2) 1-1/4 inch empty conduits shall be run from each panelboard cabinet to accessible point above finished ceiling for "future" wiring.

3. Where multiple recessed panelboards are installed adjacent to or side-by-side with each other, or other panels or cabinets, they shall have separate trims with separate hinged doors. Panelboard, panels or cabinet trims shall be square and align with each other at top.

4. Vertical height of recessed panelboard trim pieces of panelboards mounted alongside one another shall not vary less than 6 inch at bottom. Prior to ordering panelboards, Contractor shall coordinate panel trim length of panelboards shown alongside one another and provide trim pieces of equal lengths where necessary at no additional cost.

5. In no case shall horizontal distance between two (2) recessed panelboard trims of panelboards shown mounted near but separated from one another be less than 12 inch. Contractor shall coordinate panel locations shown prior to installation and either separate panelboard trims by 12 inch or mount panelboards alongside one another with trims

butting each other. Installation of panelboards alongside one another shall also meet requirements of preceding paragraph.

E. Miscellaneous:

1. Two (2) sets of keys for each panelboard shall be delivered to the Owner.
2. Circuit breakers with adjustable instantaneous magnetic trips shall be properly set.
3. Circuit breaker accessories such as shunt trip, undervoltage trip and ground fault shall be tested.

F. Electrical Identification: Reference Section 261950 for additional details.

1. Panelboard Identification: Affix panelboard nameplate on the outside panelboard trim at the top. Type in description of correct load on panelboard directories located inside the panelboard on the door. Panelboard nameplate shall include two (2) lines of engraved lettering. On top line, engrave panelboard designation shown on Panelboard Schedule. On bottom line engrave voltage phase and wire description. Panelboard nameplate shall be centered on panelboard trim above door. Nameplate shall be fastened with two (2) stainless steel or nickel-plated screws.
2. Panelboard Directory: Fill out panelboard directory cards by typing in load description. Directories shall be updated and reflect those circuit numbers and load descriptions indicated on the Record Drawings.

G. Load Adjustment: Balance all single-phase continuous loads (one and two-pole loads continuous for 3 hours or more) at each phase of a panelboard. This normally includes lighting and equipment loads but not power receptacle loads. Balancing the loads shall equalize the continuous connected load on each phase to within +/-10 percent. Panelboard branch circuit directories and record drawings shall reflect final circuit assignments.

3.9 SECONDARY UNIT SUBSTATIONS INSTALLATION AND TESTS

- A. Contractor shall install equipment in accordance with manufacturer's installation instructions and requirements of this article.
- B. Verify reinforced concrete housekeeping pad is correct size and in correct location. Reference section 260500, Concrete Work article for pad concrete requirements. Set seismic anchor bolts in concrete housekeeping pad in correct location. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL article for transformer vibration isolators and unit substation anchor bolts.
- C. Any lifting or hoisting means shall adequately support unit substation.
- D. Locate unit substation(s) above location of anchor bolts and conduit stubs. Be sure to allow for cable bending space and clearances to live parts before final positioning of unit substation.
- E. Reference Dry Type Transformers (300 kVA to 2500 kVA) Installation And Tests article for transformer installation.
- F. Reference Installation of Low Voltage Switchboards/gear article for installation.
- G. Progressively level and bolt frames together using removable bus sections, splice plates and hardware provided by unit substation manufacturer. Connect all buses together at shipping sections in accordance with manufacturer's torque specifications.
- H. Circuit breakers or switches shall be OPEN prior to making connections. Install all wire and cable taking care as to avoid possibility of future physical damage and overheating of cables. Phase conductors of circuit should be of same length. Properly provide adequate support and binding radii of wire and cables. Properly ground incoming switch or circuit breaker cubicle and conduit stubs to ground bus.
- I. Cable lugs shall be of correct size and type and be tightened to manufacturer's recommended torque values.

J. Miscellaneous:

1. GFP system on shall be performance tested by Contractor after installation at the job site. Certified test report shall be provided by Contractor and shall be submitted to Architect/Engineer for compliance.
2. Contractor shall install primary switch fuses furnished with unit substation.

K. Unit Substation Field Tests and Adjustments: Contractor shall provide certified test reports on following items. Certified test reports shall be provided in accordance with Section 260100, Testing article.

1. General:
 - a. Prior to energizing switchgear, all control and instrument wiring connections shall be inspected for workmanship and proper identification and termination.
 - b. Power feeders terminations shall be checked for correct torque values of tightness.
 - c. Check all fuses for correct ampacity and type. Also check fuse alignment in clips and continuity with ohmmeter.
 - d. After feeders are installed and switches are initially closed, check for correct operation for proper phase rotation shall be made and recorded.
 - e. Check for proper connection of grounding requirements.
 - f. Polarity wiring on current and voltage transformer shall be checked.
 - g. Check for loose nuts, bolts or screws and freedom of operating parts.
2. 5 kV Interrupter Switch Mechanical Tests:
 - a. Three (3) open-close operations of each switch.
 - b. Inspect switch(es) for alignment, freedom from binding and good contact closure.
 - c. Check interlocks of switches so switches cannot be placed into operating position when door over fuse compartment is open.
3. 600 Volt Circuit Breaker Tests:
 - a. Open and close each circuit breaker manually three (3) times.
 - b. Open and close each circuit breaker with an electric operator electrically three (3) times.
 - c. Any circuit breaker not operating correctly shall be replaced with a new unit and OPEN and CLOSE test redone.
 - d. Test all interlocks.
 - e. Operate any auxiliary devices such as undervoltage or shunt trips and auxiliary switches.
 - f. Test breaker solid-state trips with plug-in test kit as follows.
 - 1) Test breakers indicated with ground fault. Ground fault protection of breakers shall be tested by both tripping breaker and by not tripping breaker.
 - 2) Functional testing of any long time, short time setting provided on circuit breakers.
4. Insulation Test of Medium-Voltage Bus and Devices:
 - a. After removing fuses on any voltage transformer, and with circuit breakers and switches open and with primary cables disconnected and in case of unit substations with transformer disconnected perform and record tests using meter with minimum scale of 2000 megohms. Test readings shall be recorded for each 30 seconds for length of time indicated.
 - b. Hi-Pot Test:

<u>Bus and Devices</u>	<u>Minimum Megohms</u>	<u>High Potential Test Voltage/Time</u>
15 kV Bus	1000	28 kV/2 minutes
15 kV Devices	1000	28 kV/2 minutes
5 kV Bus	1000	12.5 kV/2 minutes
5 kV Devices	1000	12.5 kV/2 minutes

c. Megger Test:

<u>Bus and Devices</u>	<u>Minimum Megohms</u>	<u>Megger Test Voltage/Time</u>
15 kV Bus	1000	2500V/5 minutes
15 kV Devices	1000	2500V/5 minutes
5 kV Bus	1000	2500V/5 minutes
5 kV Devices	1000	2500V/5 minutes

3.10 INSTALLATION OF UNIT SUBSTATION LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS

- A. Verify that reinforced concrete housekeeping pad and anchors are correct size and in correct location. Reference Section 260500, CONCRETE WORK article for concrete pad requirements. Reference section 262400 - VIBRATION AND SEISMIC CONTROL for anchor bolts.
- B. Lifting or hoisting means shall adequately support the sections. Contractor shall install equipment in accordance with manufacturer's installation instructions.
- C. Locate switchboards above any conduit stubs and allow for cable bending space and clearances to live parts. Switchboards shall not be placed directly against wall but shall have minimum 1 inch air space.
- D. Connect busses together at shipping sections in accordance with manufacturer's torque specifications. Switchboard trim pieces with louvers shall have louvers directed downward.
- E. Circuit breakers or switches shall be OPEN prior to making wiring connections. Install wire and cable taking care as to avoid possibility of future physical damage and overheating of cables. Phase conductors of feeder circuit shall be of same length. Do not exceed wire and cable manufacturer's bending radius at terminations. Ground switchboard cubicles and conduit stubs to ground bus with bonding jumpers.
- F. Cable lugs shall be of correct size and type to match the conductor and be tightened to manufacturer's recommended torque values.
- G. Before energizing the switchboard, contractor shall perform visual inspection and perform 600 volt feeder insulation test as specified in Section 260100, Testing article.
- H. Install fuses of appropriate type, size and voltage.
- I. Operate all circuit breakers three (3) times manually under load. Circuit breakers failing to open and close shall be replaced at Contractor's expense.
- J. GFP system shall be performance tested by Contractor after installation at the job site. Certified test report shall be provided by Contractor and shall be submitted to Architect/Engineer for compliance.
- K. Nameplates: Refer to specification Section 261950 - ELECTRICAL IDENTIFICATION for nameplate requirements.
- L. Exposed finished sheet metal front, sides and back shall be cleaned and tape, stickers and other markings shall be removed. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.
- M. Inside of switchboards shall be vacuumed clean just prior to final observation.

END OF SECTION 264000

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 264500 – GROUNDING AND BONDING

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL GROUNDING AND BONDING REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	2
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
PART 2 - PRODUCTS		2
2.1	GROUND CONDUCTORS	2
2.2	GROUND CONNECTORS	2
2.3	GROUND RODS AND PIPES	3
2.4	GROUND AUGMENTATION	3
2.5	GROUND BUS BAR (GB)	3
2.6	MANUFACTURERS	3
PART 3 - EXECUTION		4
3.1	SEPARATELY DERIVED AC SYSTEM GROUNDING ELECTRODE	4
3.2	BUILDING GROUNDING ELECTRODE SYSTEM	4
3.3	MADE AND OTHER ELECTRODES	5
3.4	BONDING INTERIOR METAL PIPING AND EXPOSED STRUCTURAL STEEL	6
3.5	EQUIPMENT GROUNDING BUS	6
3.6	EQUIPMENT GROUNDING CONDUCTOR	6
3.7	NEUTRAL BUS	7
3.8	TRANSFORMER GROUNDING	7
3.9	GENERATOR GROUNDING	7
3.10	MOTOR FRAMES AND MOTOR CONTROLLER GROUNDING AND BONDING	7
3.11	METALLIC RACEWAYS AND OTHER ENCLOSURE GROUNDING AND BONDING	7
3.12	WIRING DEVICE GROUNDING	8
3.13	CORD AND PLUG CONNECTED EQUIPMENT	8
3.14	LIGHTING FIXTURES AND EQUIPMENT	8
3.15	GROUNDING ELECTRODE SYSTEM TEST	9

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SECTION 264500 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL GROUNDING AND BONDING REQUIREMENTS

- A. This section is intended to cover the general grounding and bonding of electrical distribution system(s) and equipment and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and as required for grounding and bonding.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install the following grounding and bonding equipment:

1. Meter boxes grounding and bonding
2. Separately derived AC system grounding electrodes
3. Building grounding electrode system
4. Bonding of interior metal piping and exposed structural steel
5. Made grounding electrodes and connections
6. Equipment grounding bus
7. Equipment grounding conductors
8. Neutral bus
9. Surge protective device (SPD)
10. Transformer grounding
11. Generator grounding
12. Automatic transfer switches (ATS)
13. Motor frames and motor controller enclosure grounding
14. Metallic raceways and other enclosure grounding and bonding
15. Telecommunications grounding system
16. Power receptacle grounding
17. Cord and plug connected equipment
18. Lighting fixtures
19. Grounding electrode system test

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of the required grounding and bonding equipment and devices:
 1. Indoor Service Switchgear: Service switchgear metallic enclosure and equipment ground bus shall be grounded with equipment grounding conductors and the conduit grounding network.
 2. Unit Substation(s): Unit substation metallic enclosure and equipment ground bus shall be grounded with an equipment grounding conductor and the conduit grounding network.
 3. New Switchboard(s): Switchboard metallic enclosure and equipment ground bus shall be grounded with an equipment grounding conductor and the conduit grounding network.
 4. Surge Protective Device (SPD): SPD shall be grounded to the switchboard or panelboard equipment ground bus in which it is located or protects.
 5. Transformers and Generator(s) (to 600 Volts): Transformers and generator(s) are separately derived AC systems and shall be grounded in accordance with NEC.
 6. Automatic Transfer Switches (ATS): The metallic enclosure and equipment ground bus of ATSs shall be grounded with an equipment grounding conductor and the conduit grounding network.

7. Panelboards: The panelboards metallic enclosure and its equipment ground bus shall be grounded with an equipment grounding conductor and the conduit grounding network.
8. Variable Frequency Drives (VFD): VFD's metallic enclosures and equipment ground buses shall be grounded with an equipment grounding conductor and the conduit grounding network.
9. Motor Controllers and Disconnects: Motor controllers and disconnect switches metallic enclosures and equipment ground buses shall be grounded with an equipment grounding conductor and the conduit grounding network.
10. Power Receptacles: Power receptacles (duplex and single) shall be grounding type unless otherwise indicated and be grounded with an equipment grounding conductor.
11. Cord and Plug Connected Equipment: All cord and plug connected equipment for AC power systems shall have an equipment grounding conductor in the cord attached to the grounding terminal of the plug.
12. Lighting Fixtures: Exposed metal parts of lighting fixtures shall be grounded with an equipment grounding conductor.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.

PART 2 - PRODUCTS

2.1 GROUND CONDUCTORS

- A. General:
 1. UL and NEC listed types shall be copper.
 2. Size: Size of conductors shall not be less than required by the NEC or Authority Having Jurisdiction (AHJ).
 3. All feeders and branch circuit raceways shall have an equipment grounding conductor.
- B. Grounding Conductors:
 1. Insulated Type: Grounding conductors run with feeders and branch circuits shall have insulation as listed in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS). Insulation of feeders and branch circuit grounding conductors up to size #6 AWG shall be green in color. Insulation of wire in sizes #4 AWG and larger are not normally available in green therefore they shall be identified with green tape.
 2. Non-Insulated Type: Grounding conductors shall be in accordance with NEC.
- C. Grounded (Neutral) Conductors: Feeder and branch circuit neutral conductors for systems to 600 volts shall have insulation as listed in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).

2.2 GROUND CONNECTORS

- A. General:
 1. UL listed type and be rated for copper connections.
 2. Ground connecting devices for a wire, cable or rebar shall match the diameter of the wire, cable or rebar. When connectors are to be connected to a bus they shall have appropriate NEMA mounting holes.
 3. Ground connectors buried below grade shall be rated for direct burial.
- B. Mechanical Type: Mechanical connectors shall have Allen set screws and be rated for 194 deg. F.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Compression Type: Compression connectors shall be fastened with matching hydraulic tool and be rated for 194 deg. F.
- D. Welded Type: Welded connectors shall be exothermic type set in appropriate mold.

2.3 GROUND RODS AND PIPES

- A. Ground rods shall be UL listed copper clad steel, 3/4 inch diameter by 10 ft. long. Ground pipes with an electrolyte shall be copper with a minimum of 2 inch diameter by 10 ft. long. A ground inspection well with cover shall be provided.

2.4 GROUND AUGMENTATION

- A. Ground augmentation shall be through the use of cement or ground augmentation material to reduce soil resistivity.

2.5 GROUND BUS BAR (GB)

- A. Copper ground bus bar shall be 1/4 inch x 3 inch x 20 inch long with wall bracket and insulators mounted on in the building where indicated. Bars shall have twenty-seven (27) sets of 5/16 inch holes, 5/8 inch on center to accommodate "A" spaced 2-hole compression lugs.

2.6 MANUFACTURERS

- A. The following manufacturers of grounding and bonding products may be used. Specific items are indicated in brackets.
- B. Grounding Conductors:
 - 1. Bare:
 - a. Thompson Lightning Protection Inc.
 - b. Heary Brothers Lightning Protection Co.
 - c. Robbins Lightning, Inc.
 - d. ERICO Inc.; (Braid)
 - e. ILSCO (Braid)
 - 2. Insulated:
 - a. Southwire Co.
 - b. Prysmian Cables and Systems.
- C. Grounded (Neutral) Conductors:
 - 1. Southwire Co.
 - 2. Prysmian Cables and Systems.
- D. Ground Connectors:
 - 1. O-Z/Gedney Co.; a unit of General Signal (buried pipe clamp)
 - 2. GALVAN Industries Inc. (buried pipe clamp 1/2 to 1 inch)
 - 3. Thomas & Betts, Electrical (60100 and 60200 compression)
 - 4. Anderson (Pipe clamps, connectors, flexible copper braid)
 - 5. ERICO Inc. (Cadweld, welded type, fence post and gate, equipotential mesh)
 - 6. Thermoweld (welded type)
 - 7. Furseweld (welded type)
 - 8. Harger Lightning Prot. Inc. (Ultraweld, welded type)
 - 9. AMP Products Corp. (wedge lock type)
 - 10. Ideal Industries, Inc.
 - 11. ILSCO Corp. (CRA-L and CRB-L compression) (TA and AU mechanical)
 - 12. Burndy (compression type)
 - 13. Greaves Corp. ("Jones Bond" or "High-Wing," mechanical type to rebars)
 - 14. Buchanan (Cytotek mechanical type)
 - 15. Mar-Tek Ind. (Branch Circuit, Term-A-Nut)

16. Thomas & Betts (cast copper connectors for raised floor post with post-bolted and wire compression connectors)
- E. Ground Rods and Pipes:
 1. Thompson Lightning Prot. Inc.
 2. Heary Brothers Lightning Prot. Co.
 3. Robbins Lightning, Inc.
 4. Harger Lightning Prot. Inc.
 5. GALVAN Industries Inc. (copper clad and stainless steel ground rods)
- F. Ground Augmentation Materials: Use to reduce the resistivity of the soil. Normally use for sandy or rocky soils.
 1. ERICO Inc. (GEM) a Ground Enhancement Material
 2. Grounding Systems LLC (EarthLink 101) conductive cement
 3. Electric Motion Co. (EMC) conductive cement No. EM-M5C
 4. LEC Inc. (GAF) Ground Augmentation Fill.
- G. Ground Bus Bars:
 1. ERICO Inc. (Telecom TGB & TMGB)
 2. Thompson Lightning Prot. Inc.
 3. Harger Lightning Prot. Inc.

PART 3 - EXECUTION

3.1 SEPARATELY DERIVED AC SYSTEM GROUNDING ELECTRODE

- A. Grounding electrode for separately derived AC systems shall be provided in accordance with NEC and be as practicable to and preferably in the same area as the grounding conductor connection to the system. The grounding electrode shall be the nearest one of the following:
 1. An effectively grounded structural metal member of the structure.
 2. An effectively grounded metal water pipe within 5 ft. from the point of entrance into the building.
 3. Made and other electrodes as specified in NEC. See the following BUILDING GROUNDING ELECTRODE SYSTEM article, where electrodes specified by A and B above are not available.

3.2 BUILDING GROUNDING ELECTRODE SYSTEM

- A. The building grounding electrode system shall be provided in accordance with NEC. If available on premises at each building or structure served, each of following and any made (rod, pipe or plate) electrodes shall be bonded together to form the "Grounding Electrode System":
 1. 10 ft. or more of metal underground water pipe plus supplemental electrode
 2. Metal frame of the building or structure where effectively grounded
 3. Concrete-encased electrode; 20 ft. of 1/2 inch (No. 4) rebar or bare copper #4 AWG in contact with the earth.
- B. Where none of the above is available provide made electrodes in accordance with the following MADE AND OTHER ELECTRODES article.
- C. Grounding Electrode Conductor:
 1. Material: Grounding electrode conductor shall be solid or stranded copper and be insulated or bare and be installed in accordance with NEC.
 2. Size: Size of grounding electrode conductor shall be in accordance with NEC.
 3. Method of Connection: Grounding electrode conductor shall be connected by exothermic welding, listed pressure connectors, listed clamps or other listed means. "Listed" shall be as defined in NEC.

- D. Metal Underground Water Pipe: Water pipe must meet NEC. Grounding connections to underground metallic water pipes shall be made with cast bronze ground clamp as manufactured by O-Z/Gedney. All clamps shall be suitable for direct soil burial.

3.3 MADE AND OTHER ELECTRODES

- A. General: Made and other electrodes shall be provided in accordance with NEC. Bonding is very important and shall be provided by personnel having at least 2 years experience in the required type bonding used. Size of grounding electrode conductor to the made or other electrode shall be in accordance with NEC. Where a larger size is indicated on the drawings it shall be used. Grounding electrode conductor connections to the electrodes shall be compression connected or exothermic welded in place.
- B. Rod Electrodes:
 - 1. Rods: Ground rods shall be minimum 8 ft. long and minimum of 5/8 inch diameter copper clad steel. Made ground rods on grade shall be separate from any lightning protection system ground rods and be separated by at least 6 ft., however, they shall be connected together to limit the voltage difference between the two systems.
 - 2. Method of Connection: Grounding electrode conductor shall be connected by exothermic welding, listed pressure connectors, listed clamps or other listed means. "Listed" shall be as defined in NEC. Connectors shall be listed for direct soil burial.
 - 3. Clean Connection: Grounding electrode conductors and rod electrodes shall be clean and dry to ensure good contact. Wire brush and cleaning solvent shall be used in accordance with manufacturer's installation instructions.
 - 4. Earth Contact: Rod electrodes shall be driven to a vertical depth of 8 ft. in contact with the soil unless a rock bottom is encountered. Electrodes hitting a rock bottom may be relocated or driven at an oblique angle not to exceed 45 degrees from vertical or be buried in a trench at least 30 inch deep.
 - 5. Spacing: Where more than one rod electrode is required they shall be no closer than 6 ft.
- C. Plate Electrodes:
 - 1. Method of Connection: Grounding electrode conductor shall be connected by exothermic welding, listed pressure connectors, listed clamps or other listed means. "Listed" shall be as defined in NEC. Connectors shall be listed for direct soil burial.
- D. Connectors: Exothermic welding shall not be done on rainy or wet days unless CADWELD Exolon electric system is used.
- E. Electrolytic Pipe Electrode:
 - 1. Electrolytic pipe electrode shall be a 2 inch to 2-5/8 inch hollow copper tube 10 ft. long filled with metallic or mineral salts located in a ground box or behind an access well cover. Copper tube shall have a stranded #4/0 AWG copper pigtail welded to the side to be used for attachment of the grounding electrode conductor and as a test point.
 - 2. Inspection Well: Ground box or access wall shall have a removable protective cover. Box or cover shall be flush with grade to allow access to the test point and the addition of ground enhancement material.
 - 3. Ground enhancement material shall be used as a backfill to reduce the soil's resistivity.
 - 4. Installation:
 - a. Auger or core a hole (minimum 6 inch diameter) 6 inch deeper than the length of the rod.
 - b. Place the unit into the hole (or trench for horizontal models) so that the top of the unit is 6 inch below grade. Top of rod must have free-air circulation, be free of debris, and be under a protective cover box.
 - c. Mix ground enhancement material and backfill the electrode up to depth indicated.
 - d. Place protective cover box over the top (flushed to grade level) for easy access.

- e. Connect the exothermic pigtail (provided) to grounding electrode conductors. Bury grounding conductor minimum 2 inch below grade. Backfill conductor with ground enhancement material.
 - f. Ground System Testing: Conduct certified measurements after the installation of the ground system utilizing an earth resistance meter in accordance with IEEE Standard 3 point fall-of-voltage method. Submit resistivity measurements on the grounding system to the Engineer for approval.
 - F. Test: Reference GROUNDING ELECTRODE SYSTEM TEST article.
- 3.4 BONDING INTERIOR METAL PIPING AND EXPOSED STRUCTURAL STEEL
- A. General: Bonding jumpers shall be sized in accordance with NEC Table 250.66 as appropriate. Jumpers shall be installed in accordance with NEC. Points of attachment of bonding jumper shall be accessible.
 - B. Interior Metal Water Piping: Reference NEC for additional details. Interior metal water piping systems shall be bonded to the service equipment enclosure, the grounded conductor at service, a correctly sized grounded electrode conductor or to the grounding electrode used.
 - C. Exposed Interior Structural Steel: Reference NEC for additional details. Structural steel connected to form a steel building frame and not intentionally grounded but which may become energized shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor of sufficient size, or to the one or more grounding electrodes used.
- 3.5 EQUIPMENT GROUNDING BUS
- A. Each new switchgear or switchboard section, and panelboard shall have an accessible equipment grounding bus for terminating the equipment grounding conductors (copper wire) run in the raceways and the bonding jumpers from the metal conduit grounding bushings.
- 3.6 EQUIPMENT GROUNDING CONDUCTOR
- A. Equipment grounding conductors shall be used for grounding non-current carrying metallic parts of electrical equipment used on job listed in NEC and other equipment shown on the drawings. Equipment grounding conductors (copper wire, metallic conduit, cable tray etc.) shall be terminated on the equipment ground bus.
 - B. Size: Equipment grounding conductors (copper wire) shall meet 2002 NEC Table 250.122 unless a larger size is indicated on the drawings. Minimum size for jobs in St. Louis County shall be #12 AWG.
 - C. Material and Insulation: Grounding conductors shall be copper. Equipment grounding conductors shall have green insulation or green tape marking or be bare as required by the NEC. Reference Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS) and Conductor Color Coding subparagraph for additional details of grounding conductors for systems to 600 volts.
 - D. Raceway: Equipment grounding conductors shall be run inside the conduit or raceway with phase conductors or wires. Non-metallic conduits or raceways shall have grounding conductors.
 - E. Parallel Phase and Equipment Ground Conductors in Multiple Raceways: Where parallel phase conductors No. 1/0 and larger are run in multiple raceways, the equipment grounding conductor, where used, shall be run in parallel in each raceway.
 - F. Larger Equipment Grounding Conductors Due to Long Conduit Runs: Contractor shall verify the sizes of conduit shown on the drawings and increase their size where necessary to comply with the following:

1. For metallic conduit runs 300 ft. and longer with 30 amp, 120 volt circuits using 1/2 inch or 3/4 inch conduit, the equipment grounding conductor shall be minimum #8 AWG to reduce the impedance to ground.
2. For metallic conduit runs 280 ft. and longer with 40 amp, 120 volt circuits using 3/4 inch conduit, the equipment grounding conductor shall be minimum #8 AWG to reduce the impedance to ground.

3.7 NEUTRAL BUS

- A. Neutral bus of each panelboard switchboard or switchgear shall be insulated from equipment enclosure and have provisions for terminating all of the branch circuit and feeder neutral (grounded) conductors.
- B. Neutral grounded bus for each building's secondary service or separately derived system shall be connected to the equipment grounding conductors in only one place. This shall be in the main service switchboard panelboard for a building's secondary service or at the separately derived system's disconnecting means enclosure. This removable link shall be a "main bonding jumper" as noted in SECONDARY SERVICE AND UNIT SUBSTATION GROUNDING SYSTEM article, Paragraph "Main Bonding Jumper at Secondary Services" for the electrical service or a "bonding jumper" for a separately derived system sized in accordance with NEC Table 250.66.

3.8 TRANSFORMER GROUNDING

- A. Two-winding transformers with secondary neutrals that have no direct connection to the primary (supply-side) with the grounded (neutral) conductor are defined as separately derived AC systems and shall be grounded in accordance with preceding SECONDARY SERVICE AND UNIT SUBSTATION GROUNDING SYSTEM article NEC Article 250.30.

3.9 GENERATOR GROUNDING

- A. Generators (To 600 Volts):
 1. Generators providing 120/208 volt or 277/480 volt, 3 phase, four-wire wye AC power that are wired to four-pole automatic transfer switches are defined as separately derived systems and shall be grounded in accordance with preceding SECONDARY SERVICE AND UNIT SUBSTATION GROUNDING SYSTEM article NEC Article 250.30.
 2. Grounding Separately Derived AC System: Center output lead of generator shall be grounded to the neutral of load on the automatic transfer switch through operation of the fourth contact pole. Generator center output lead shall also be grounded to generator housing and to grounding electrode in accordance with 2002 NEC Article 250.30.

3.10 MOTOR FRAMES AND MOTOR CONTROLLER GROUNDING AND BONDING

- A. Frames of motors and enclosure of motor starters and metallic enclosures of other electrical devices shall be electrically bonded to metallic conduit grounding network.
- B. Frames of stationary motors and metal terminal housings shall be grounded with an equipment grounding conductor and by conduit grounding bushings.

3.11 METALLIC RACEWAYS AND OTHER ENCLOSURE GROUNDING AND BONDING

- A. Non-conductive paint, enamel or similar coating shall be removed at threads and contact surfaces. Metallic raceways shall be effectively bonded by mechanically securing to metallic enclosures, frames or structures to which they are attached to by listed fittings that provide good metal-to-metal contact. Bonding between raceways and enclosures shall provide effective electrical continuity with capacity to safely conduct fault current likely to be imposed on the bonding.
- B. Metallic raceways attached to metallic enclosures, frames and structures of substations, switchgear, switchboards, automatic transfer switches, motor controllers, disconnect switches,

panelboards or boxes shall be effectively bonded with listed fittings to provide good metal-to-metal contact.

- C. **Metallic Covers or Wall Plates:** Metallic covers, faceplates or wall plates for metallic conduit fittings, pull boxes, junction boxes, voice/data outlets, and power receptacle outlet boxes shall be grounded by tightening all available metallic screws.
- D. **Bonding Over 250 Volts:** Rigid and IMC conduits installed between metallic enclosures with circuits over 250 volts to ground shall have threaded couplings to maintain the bonding between the enclosures and the rigid steel or IMC raceways.
- E. **Surface Metal Raceway Grounding:** All surface metal raceway installations shall be equipped with insulated green equipment grounding conductor. Equipment grounding conductor shall be bonded to grounding terminal of the contained power receptacles without isolated ground terminals and each section of the surface metal raceway. Equipment grounding conductor shall be attached to the panelboard equipment ground bus.

3.12 WIRING DEVICE GROUNDING

A. In Metal Boxes:

- 1. **Wiring Device Grounding:** Power receptacles and wall switches shall have self-grounding feature via metal grounding clip or metal mounting screw as specified. Clip shall ensure ground continuity between wiring device's metal mounting strap or yoke and the metal wall box. Receptacles having a grounding screw shall be grounded with an equipment grounding conductor terminated on the ground screw.
- 2. **Cover Mounted Receptacles:** For cover mounted power receptacles located on surface-mounted metallic boxes, electrical continuity shall be provided by an equipment bonding jumper between the grounded outlet box and the receptacle's grounding terminal.
- 3. **Box Mounted Receptacles:** For box mounted power receptacles located on surface or flush-mounted metallic boxes, electrical continuity shall be provided by the supporting screws used to fasten the receptacle's device yoke to the grounded outlet box and by a grounding conductor fastened to the ground screw on the receptacle.

B. In Non-Metallic Boxes:

- 1. **Wiring Device Grounding:** Power receptacles, wall switches and dimmers shall have an equipment grounding conductor or bonding jumper terminate on the power receptacle, wall switch or dimmer.
- 2. **Cover Mounted Receptacles:** For cover mounted power receptacles located on surface-mounted non-metallic boxes, electrical continuity shall be provided by an equipment bonding jumper between the equipment grounding conductor in the outlet box and the receptacle's grounding terminal.

- C. **Power Receptacle Tests:** Power receptacles shall be tested in accordance with Section 261400 - WIRING DEVICES, PART 3.

3.13 CORD AND PLUG CONNECTED EQUIPMENT

- A. Cord and plug connected equipment shall have its non-current carrying metal parts grounded by an equipment grounding conductor run with the power supply conductors in the cord that is attached to a grounding type plug.
- B. Plugs shall match the grounding type power receptacle's NEMA configuration.

3.14 LIGHTING FIXTURES AND EQUIPMENT

- A. Lighting fixtures with exposed metal parts shall be provided with a means for connecting an equipment grounding conductor as specified in 2002 NEC Article 250.118. The equipment grounding conductor shall be that copper grounding conductor pulled with the branch circuit wiring unless otherwise indicated or required.

B. Metal Poles:

1. Metal poles for lighting fixtures shall be provided with a grounding terminal accessible at the handhole or hinged base for connection of the equipment grounding conductor.
2. Metal poles shall be grounded with separate grounding conductor and ground rod. Grounding conductor shall be in 1/2 inch conduit run at right angles to power conduits. Conduit for grounding conductor shall extend a minimum of 2 ft. from pier below grade.

C. The track of the track lighting systems shall be securely coupled to each other in accordance with manufacturer's installation instructions to maintain grounding throughout the track system.

3.15 GROUNDING ELECTRODE SYSTEM TEST

A. Ground resistance measurements shall be made on each individual grounding electrode system and on each basic grounding system installed under this contract. Individual doing the testing must have a minimum experience of fifty (50) such tests in the past 2 years.

B. Made Electrodes:

1. Ground resistance measurements of made electrodes shall be made only in normally dry weather and not less than 48 hours after rainfall. Readings shall not be more than 25 Ohms. Where more than 25 Ohms is measured additional ground electrodes (rod or plate type) shall be provided and new tests performed. Multiple ground electrodes shall not be placed closer than 6 ft. from each other.
2. Tests shall be performed with a Biddle Megger (null balance) Earth Tester, or by the 3 point method described in IEEE Green Book Standard 142-1972, paragraph 4.4.2, using two (2) auxiliary ground rods. Latter method requires the use of AC test current.

C. Certified Test Report: Certified test report shall be provided in accordance with Section 260100, TESTING article.

1. Ground resistance measurements required above shall be taken and certified by the Contractor to the Owner.
2. Contractor shall submit in writing to Owner, upon completion of contract, time and date of test, measured ground resistance of each grounding electrode system of each grounding system. Submittal shall also indicate location, size and type of each grounding electrode system and each grounding system, including all supplementary electrodes required, hours since last rainfall, soil conditions (wet, damp, dry), and soil temperature at time measurements were taken.
3. Contractor shall also furnish complete data on methods of testing and instruments used in tests.

END OF SECTION 264500

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 265100 – INDOOR LIGHTING

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	SCOPE OF WORK	1
1.3	GENERAL LIGHTING REQUIREMENTS	1
1.4	SUBSTITUTIONS	2
1.5	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
1.6	GROUNDING AND BONDING SYSTEMS	3
PART 2 - PRODUCTS		3
2.1	INDOOR LIGHTING FIXTURES	3
2.2	FIXTURE LENSES	4
PART 3 - EXECUTION		5
3.1	INDOOR LIGHTING FIXTURE INSTALLATION	5
3.2	LIGHTING FIXTURE SCHEDULE	7

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SECTION 265100 - INDOOR LIGHTING

PART 1 - GENERAL

1.1 REFERENCES

- A. Drawings and all sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 SCOPE OF WORK

- A. Contractor shall furnish and install all lighting fixtures, lamps, ballast and controls systems specified. Include all labor and material for the complete electrical work herein specified, shown on drawings and as required for the complete and proper performance of the lighting systems and in accordance with all applicable codes.

1.3 GENERAL LIGHTING REQUIREMENTS

- A. This section is intended to cover indoor lighting equipment and its installation applicable to the Contractor's work.
- B. Contractor shall include all labor and material as required for complete and proper performance of material, equipment and systems specified.
- C. Lighting Fixture Schedule: The Lighting Fixture Schedule and the lighting specifications sections are complementary. Any item or feature called for by one shall be required by both. In the event of a conflict the Contractor shall notify the Engineer prior to bid.
- D. First Named Manufacturer: Manufacturer and catalog number listed first for each fixture type in the "Manufacturer catalog number" column of the fixture schedule or specifications or notes shall be the basis for design and sets the standards of performance, fabrication and aesthetics required for the project.
- E. Equals: For each fixture type, only products of those manufacturers listed in the "Manufacturer catalog number" column of the fixture schedule, specifications or drawing notes, which meet or exceed the performance, fabrication and aesthetics of the first named manufacturer shall be considered equals. Equals may be submitted for review in accordance with the requirements for shop drawings in this section.
- F. Substitutions: The products of any manufacturer not listed on the fixture schedule shall be considered a substitution. Any substitutions must be submitted to the Engineer by the Contractor for review prior to bid submittals in accordance with the requirements of this section. The Engineer reserves the right to reject any substitution submittal.
- G. Manufacturer Numbers: The listed manufacturer numbers may not be complete. The Contractor is responsible for furnishing fixtures which comply with the manufacturer number indicated as well as all other criteria noted in the fixture schedule, the fixture schedule notes and Division 26 specifications. The Contractor/manufacturer shall contact Engineer prior to bid, regarding any conflicts between the catalog number, fixture schedule or specification.
- H. One Manufacturer per Fixture Type: Contractor shall use only one fixture manufacturer per fixture type and shall use that fixture on the entire project. Mixing of a fixture type by different manufacturers will not be allowed.
- I. Replacement of Defective or Damaged Parts:
 - 1. Work shall be completed prior to Architect/Engineer's final observation.
 - 2. Contractor shall replace all defective drivers or fixtures at completion of contract work.
 - 3. Sagging, broken, cracked, dented or otherwise damaged lenses or louvers in lighting fixtures shall be replaced by Contractor. Replacements shall be lenses or louvers of same type and color as those damaged.

J. Cleaning of Fixtures:

1. Work shall be accomplished prior to Architect's/Engineer's final observation.
2. Cleaning:
 - a. Markings and Loose Material: Fixtures shall be free of visible labels, markings and lamp retainer gaskets.
 - b. Lenses and Louvers: All lenses and louvers on fixtures shall be cleaned and free of fingerprints.

K. Lighting fixtures, and all associated components, shall have appropriate UL label for application being installed and comply with ASTM, IES and NEMA Standards as well as applicable codes.

L. Extruded Fixture Housings: Housings shall be smooth and free of sharp edges. Holes shall only be provided in locations to match the jobs mounting and wiring requirements.

M. Lighting Fixture Supports: Lighting fixtures shall be supported independent of outlet boxes unless the box is listed for the weight to be supported.

N. Light Fixture Warranty: Lighting fixtures shall have a minimum 5 year manufacturers warranty, or longer as specified in Light Fixture Schedule or Lighting Plans.

1.4 SUBSTITUTIONS

A. See Section 260100. It is the Contractor's responsibility to submit a product of quality and performance equal-to or better-than first named manufacturer. Substitution submittals shall also meet the following criteria for proper evaluation of substitution equipment to meet job requirements.

B. Lighting Fixture Substitution Proposal: Contractor shall submit lighting fixtures proposed for substitutions for approval. Submittal shall include, but not be limited to the following:

1. Itemized comparison of proposed substitutions with product specified and detailed list of differences.
2. All information described in SHOP DRAWING SUBMITTAL REQUIREMENTS article.
3. Details on applicable field adjustments of lenses, louvers, lamps, or the complete fixture.
4. Construction or installation drawings, to scale, illustrating mounting procedures for each ceiling type used on the project.

1.5 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

A. See Section 260100. Shop drawings shall include but not be limited to the following:

1. General: For lighting fixtures and other equipment specified in this section, Contractor shall submit brochure indexed alphabetically in accordance with fixture identification tabbed for each type fixture. Submittals shall clearly identify catalog numbers and special features for each piece of equipment.
2. Fixture Submittals: Submittal of fixtures listed shall include the following:
 - a. Product Data Information:
 - 1) LED and driver product data information shall be included with fixture submittals.
 - 2) Current manufacturer's product data sheet (copies are not acceptable) or construction drawing for each light fixture type. Duplication of types on a single data sheet or drawing is not acceptable.
 - 3) Fixture dimensions, electrical ratings and weight.
 - 4) Luminaire photometric test report issued by an approved independent testing laboratory. Tests shall have been conducted in accordance with recommended testing procedures of IES and include following information:
 - a) Manufacturer's name, catalog number and cut sheet.
 - b) Candlepower data, presented both graphically and numerically, in 10 degree increments (0, 5, 15, 25, etc.). Data shall be developed for

- both up and down light, normal, parallel, and at 22.5, 45 and 67.5 when light output is asymmetrical.
- c) Zonal lumens stated numerically at 0-30, 0-40, 0-60, 0-90, and where applicable 90-120, 90-130, 0-180.
- d) Coefficients of utilization in numerical form.
- e) Total luminaire efficiency.
- 5) Fixture options, finishes, electrical characteristics, LED type, driver type and warranty, louver finish and cell quantity, lens thickness and type.
- 6) Batteries and warranty.
- 7) Manufacturer supplemental data sheets on all applicable accessories including but not limited to air handling data, wire guards; modular connection, etc.
- b. Samples:
 - 1) Provide when requested by Architect/Engineer, non-returnable sample fixture fitted with appropriate lamp, 120 volt components, and 6 ft. grounded power cord and plug.
 - 2) Sample of Finishes: Submit chip samples for finishes and colors noted on lighting fixture schedule to be selected by Architect. Chip shall be minimum 4 inch square and shall be a true sample of finish with fixture material and not merely color. Submittal shall include complete description of finishing process.

1.6 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of lighting fixtures and equipment shall be provided in accordance with NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for grounding of exposed conductive parts of lighting fixtures and equipment using an equipment grounding conductor.

PART 2 - PRODUCTS

2.1 INDOOR LIGHTING FIXTURES

- A. General:
 - 1. Unless otherwise indicated lighting fixtures shall be furnished and installed by Contractor in accordance with latest NEC.
 - 2. Fixture/Ceiling Compatibility: Contractor shall verify final size and type of ceiling construction prior to ordering recessed lighting fixtures. Contractor shall provide correct size and type mounting frame to match the ceiling construction.
 - 3. Post Painting: Fixture bodies, end caps, and other parts that are pre-painted prior to forming or cutting shall be post-painted on all edges or surfaces where paint was removed or damaged.
 - 4. Mounting hardware to fixtures supported off outlet boxes shall be tight.
- B. Materials and Applications:
 - 1. Bracket Mounted Fixtures: Bracket-mounted fixtures shall be specifically designed for this type installation. Contractor shall verify wall or ceiling construction prior to ordering and provide all accessories and blocking required.
 - 2. Surface Mounted Fixtures:
 - a. Ceiling Mounted: Surface-mounted fixtures on low-density fiberboard ceiling material shall conform to NEC.

3. Wall Mounted Fixtures: Contractor shall provide fixtures and required accessories. Contractor shall verify wall construction prior to ordering and provide all accessories required.
4. Cable Suspended Fixtures:
 - a. Contractor shall provide fixtures, aircraft cable, power cords, canopies, J-boxes, and required accessories to hang and power fixtures in accordance with local code authority.
 - b. Fixtures with integral drivers shall be centerline loaded or equipped with counter weights for balancing.
 - c. Aircraft cables shall be adjustable to meet mounting heights indicated for fixtures.
 - d. Fixtures shall be provided with protective bagging or films suitable to remain on fixture while energized until completion of construction.
5. Pendant Mounted Fixtures:
 - a. Contractor shall provide fixtures, pendant and required accessories.
 - b. Integral drivers shall be centerline loaded or equipped with counter weights.
 - c. Fixture shall have pendants of special length and integral drivers.
 - d. Fixtures shall be provided with protective bagging or films suitable to remain on fixture while energized until completion of construction.
6. Standby Emergency Lighting Units:
 - a. Emergency units shall have either unit-mounted or remote-mounted battery-powered PAR (sealed beam) or LED lamps as specified. Lamp heads on unit shall be fully adjustable horizontally and vertically.
 - b. Units shall have maintenance-free rechargeable batteries, solid-state charger, charging LED, power failure switching relay, test pushbutton and AC lockout switch. Units shall be provided with mounting brackets.
 - c. Batteries shall provide 87.5 percent of voltage for at least 90 minutes.
 - d. Batteries shall have minimum 3 year warranty.
7. Exit Lights:
 - a. Exit lights shall be LED type as indicated, and have chevrons to indicate direction of egress.
 - b. Exit lights shall be compliant with latest IBC and NFPA requirements for lamp quantity, lettering size and footcandle level.
 - c. Standby Emergency Lighting Unit: Integral battery powered exit light unit shall meet UL 924. Unit shall meet UL standard specifications for testing, material, lettering size, and luminance performance of exit lights at the end of one minute and after 90 minutes while in emergency or battery mode.
8. LED Fixtures:
 - a. Contractor shall provide all system components including drivers, LED units, connectors, heat sinks, and controllers for a complete and operational system.
 - b. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- C. Manufacturer: Manufacturer of indoor lighting fixtures shall be as indicated on Lighting Fixture Schedule or noted on plans.

2.2 FIXTURE LENSES

- A. General:
 1. Lenses shall meet applicable requirements of latest UL, ASTM, IES, and NEMA standards as well as building code in effect.
 2. Unless otherwise specified lenses shall be retained firmly in a metal frame by clips or clamping ring in such manner as to allow expansion and contraction of lens without distortion or cracking.

3. Lenses for the same type of lighting fixture shall be manufactured by a single manufacturer to provide consistency in lighting output, color and refraction.

PART 3 - EXECUTION

3.1 INDOOR LIGHTING FIXTURE INSTALLATION

A. General:

1. Lighting Fixture Location:

a. General:

- 1) Refer to Architectural Reflected Ceiling Plan and elevations for location of fixtures unless noted otherwise.
- 2) Notify Architect/Engineer prior to rough-in for any deviation required due to conflicts in the field, for approval.
- 3) Where not indicated by call out or dimension, fixtures located in lay-in ceiling tiles shall be centered in tile.
- 4) Pendant mounted fixtures shall be hung plumed and aligned with each other and Architectural partitions, soffits, or ceilings unless noted otherwise.
- 5) Fixtures shall be located in accordance with required code clearances.
- 6) To help to prevent the possibility of fires, the installation of recessed incandescent light fixtures shall meet NEC for temperature and clearance requirements.

- b. Lighting Fixtures in Mechanical Rooms: Lighting fixture locations shown in mechanical rooms are tentative; modify to avoid interference with ducts and piping. All fixtures shall be pendant mounted independent of ductwork or piping using 15 degree swivel type hangers of required length. Hangers shall be hung from building structure or U-type channel framing members hung from the building structure spanning the ductwork or piping. Fixtures shall be located where there will be no obstruction. Mounting heights may vary to suit field conditions, except that no fixture shall be mounted less than 7 ft. above finished floor.

2. Fixture Supports:

a. General:

- 1) Fixtures shall be installed to meet NEC. Contractor shall provide supports and fasteners for all lighting fixtures. Fixtures shall not be supported directly from ceiling tile, ductwork, piping, or horizontal conduits.
- 2) Supports shall maintain the fixture position without causing the ceiling, wall or partition to deflect.
- 3) Lighting fixtures shall be anchored to the building's structural members above the ceiling. Lighting fixture's body shall be provided with one anchor and one support wire if lighting fixture is 23 inch or less in length. If lighting fixtures is greater than 23 inch in length a minimum of two (2) anchors and two (2) support wires shall be provided one at opposite diagonal corners. Quantities of supports required are subject to approval by Local Code Enforcing Authority.
- 4) Fixtures on walls or partitions shall be anchored to structural members within wall or partition.
- 5) Spanning Ductwork, Piping or Conduits: Where lighting fixtures cannot be supported from hangers, wires or rods run directly above fixture to structure above, due to interfering ductwork, piping or conduits, Contractor shall provide U-type channel framing members hung from building structure spanning the ductwork, piping, or conduits to support the lighting fixtures. Channel framing members shall be as specified in Section 261900 - EQUIPMENT SUPPORTING DEVICES.

- 6) Contractor shall provide adequate support for lighting fixture by rigidly supporting recessed outlet box in finished areas or surface-mounted box in unfinished areas.
3. Cleaning:
 - a. Markings and Loose Material: Fixtures shall be clean and free of visible labels, markings and lamp retainer gaskets prior to final observation.
 - b. Lenses and louvers shall be cleaned. Lenses shall be cleaned on both sides. Fingerprints and smudges on louvers shall be completely removed. Shipping material left inside fixtures shall be removed.
 - B. Bracket Mounted:
 1. Lighting fixtures shall be mounted plumb and square and be tight to mounting surface.
 2. Fixtures having wood or metal fascia plate shall have:
 - a. Carefully squared fascia ends that make neat, vertical hairline joint on continuous runs.
 - b. Appearance of a continuous smooth run along walls as shown on the Contract Drawings.
 - c. End covers or closures with finish same as fascia.
 - d. Inside and outside corners with finish same as fascia.
 - e. Fascia corners, ends and joints shall be free of light leakage and fastening hardware shall be hidden from view.
 - f. Any fascia, cover, closure or corner failing to meet Architect/Engineer's approval shall be replaced by Contractor.
 - C. Surface Mounted:
 1. Ceiling Mounted: Fixtures surface mounted on ceiling in continuous rows shall be mounted in exact horizontal alignment and free of vertical deflection and angular jointing.
 2. Cabinet or Counter Mounted: Fixtures surface mounted to cabinets above counter tops shall be centered on available space. Fixtures shall be mounted to bottom of cabinet or on counters as appropriate. Provide spacer between cabinet or counter and top of fixture to allow circulation of air to prevent overheating of cabinet or counter. No mounting hardware shall protrude through the bottom of the cabinet.
 3. Fixtures mounted in rows along T-bars shall be supported independent of ceiling with B-Line No. IDS clips.
 - D. Wall Mounted:
 1. Fixtures and trims shall be square and plumb. Openings around fixture trims shall be filled and finished with appropriate material.
 2. Surface-mounted fixtures and recessed-mounted fixture trim pieces shall be tight against the mounting surface.
 3. Wall-mounted fixtures shall be mounted to appropriate box.
 - E. Cable Suspended:
 1. Fixture shall be hung via aircraft cable mounted tight to the fixture hanger, junction box or canopy as appropriate.
 2. Where fixtures are in rows, bottom of the fixtures shall be at the same height above floor.
 3. Power Cords:
 - a. Cords shall not penetrate ceiling plenums.
 - b. Cords shall terminate in approved J-box located in accordance with code.
 - c. Cords installation shall be consistent among fixtures of the same type; see Fixture Schedule and/or details.
 4. Dead Zone: For fixtures with flexible pendants, provide a dead zone or clearance in all directions from the fixture to other fixtures or objects. To locate the dead zone draw an arc from the vertical point of attachment of the pendant at the ceiling, to 45 degrees in

both directions. The radius of the arc shall be equal to the pendant length plus the fixture depth. This will help prevent collision with other objects during seismic action causing a pendant swing to 45 degrees.

F. Pendant Mounted:

1. Fixture pendants shall be plumb and be mounted tight to junction box or canopy.
2. Where fixtures are in rows, bottom of fixtures shall all be same height above floor.
3. Dead Zone: For fixtures with flexible pendants, provide a dead zone or clearance in all directions from the fixture to other fixtures or objects. To locate the dead zone draw an arc from the vertical point of attachment of the pendant at the ceiling, to 45 degrees in both directions. The radius of the arc shall be equal to the pendant length plus the fixture depth. This will help prevent collision with other objects during seismic action causing a pendant swing to 45 degrees.
4. Cover plates or canopies shall be screwed tight to box. Cover plates or canopies on recessed boxes shall meet flush with the ceiling.

G. LED Fixtures: Install LED fixtures in such a way as not to compromise their ability to dissipate heat. Consult manufacturer to ensure installation will not result in reduced system life.

H. Standby Emergency Lighting Units:

1. Units shall be mounted fixed in place where indicated and be wired to normal unswitched power feeding lighting within space.
2. Test: Units shall be tested in darkened space after installation to verify the following:
 - a. That relay operates on loss of normal power by de-energizing panelboard circuits feeding normal lighting and switching on battery power.
 - b. Integral and remote light heads are properly aimed and swivel joint tightened.

I. Exit Lighting Fixtures:

1. Exit light fixtures faces shall be perpendicular and square to surrounding surfaces. Exit lights with arrows shall point in appropriate direction of means of egress.
2. Battery powered exit lights shall be tested by de-energizing the circuit feeding the exit lights.

3.2 LIGHTING FIXTURE SCHEDULE

- A.** See Lighting Fixture Schedule and Notes on Lighting Plans for fixture specifications.

END OF SECTION 265100

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 265200 – OUTDOOR LIGHTING

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	SCOPE OF WORK	1
1.3	GENERAL LIGHTING REQUIREMENTS	1
1.4	SUBSTITUTIONS	2
1.5	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
1.6	GROUNDING AND BONDING SYSTEMS	3
PART 2 - PRODUCTS		3
2.1	OUTDOOR LIGHTING FIXTURES	3
2.2	FUSING LIGHTING FIXTURES AND POLES	4
2.3	METAL LIGHTING POLES	4
2.4	CONCRETE BASES FOR LIGHTING POLES (LESS THAN 50 FT.)	5
PART 3 - EXECUTION		6
3.1	OUTDOOR LIGHTING FIXTURE INSTALLATION	6
3.2	INSTALLATION OF FUSES IN LIGHTING FIXTURES AND POLES	6
3.3	METAL LIGHTING POLE INSTALLATION	6
3.4	INSTALLATION OF CONCRETE BASES FOR LIGHTING POLES (LESS THAN 50 FT.)	7
3.5	LIGHTING FIXTURE SCHEDULE	8

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SECTION 265200 - OUTDOOR LIGHTING

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 SCOPE OF WORK

- A. Contractor shall furnish and install all poles, bases, lighting fixtures, lamps and ballasts.

1.3 GENERAL LIGHTING REQUIREMENTS

- A. This section is intended to cover outdoor lighting equipment and its installation applicable to the Contractor's work.
- B. Contractor shall include all labor and material as required for complete and proper performance of material, equipment and systems specified.
- C. Lighting Fixture Schedule: The Lighting Fixture Schedule and the lighting specifications sections are complementary. Any item or feature called for by one shall be required by both. In the event of a conflict the Contractor shall notify the Engineer prior to bid.
- D. First Named Manufacturer: Manufacturer and catalog number listed first for each fixture type in the "Manufacturer catalog number" column of the fixture schedule or specifications or notes shall be the basis for design and sets the standards of performance, fabrication and aesthetics required for the project.
- E. Equals: For each fixture type, only products of those manufacturers listed in the "Manufacturer catalog number" column of the fixture schedule, specifications or drawing notes, which meet or exceed the performance, fabrication and aesthetics of the first named manufacture shall be considered equals. Equals may be submitted for review in accordance with the requirements for shop drawings in this section.
- F. Substitutions: The products of any manufacturer not listed on the fixture schedule shall be considered a substitution. Any substitutions must be submitted to the Engineer by the Contractor for review prior to bid submittals in accordance with the requirements of this section. The Engineer reserves the right to reject any substitution submittal.
- G. Manufacturer Numbers: The listed manufacturer numbers may not be complete. The Contractor is responsible for furnishing fixtures which comply with the manufacturer number indicated as well as all other criteria noted in the fixture schedule, the fixture schedule notes and Division 26 specifications. The Contractor/manufacturer shall contact Engineer prior to bid, regarding any conflicts between the catalog number, fixture schedule or specification.
- H. One Manufacturer Per Fixture Type: Contractor shall use only one fixture manufacturer per fixture type and shall use that fixture on the entire project. Mixing of a fixture type by different manufacturers will not be allowed.
- I. Replacement of Defective or Damaged Parts:
 - 1. Work shall be completed prior to Architect/Engineer's final observation.
 - 2. Contractor shall replace all defective LED's and ballasts at completion of contract work.
 - 3. Sagging, broken, cracked, dented or otherwise damaged lenses or louvers in lighting fixtures shall be replaced by Contractor. Replacements shall be lenses or louvers of same type and color as those damaged.
- J. Cleaning of Fixtures:
 - 1. Work shall be accomplished prior to Architect's/Engineer's final observation.

2. Cleaning:

- a. Markings and Loose Material: Fixtures shall be free of visible labels, markings and retainer gaskets.
- b. Lenses and Louvers: All lenses and louvers on fixtures shall be cleaned and free of fingerprints.

K. Lighting fixtures shall have appropriate UL label for application being installed and comply with ASTM, IES and NEMA Standards as well as applicable codes.

L. Extruded Fixture Housings: Housings shall be smooth and free of sharp edges. Holes shall only be provided in locations to match the jobs mounting and wiring requirements.

1.4 SUBSTITUTIONS

A. See Section 260100. It is the Contractor's responsibility to submit a product of quality and performance equal-to or better-than first named manufacturer. Substitution submittals shall also meet the following criteria for proper evaluation of substitution equipment to meet job requirements.

B. Lighting Fixture Substitution Proposal: Contractor shall submit lighting fixtures proposed for substitutions for approval. Submittal shall include, but not be limited to the following:

- 1. Itemized comparison of proposed substitutions with product specified and detailed list of differences.
- 2. All information described in SHOP DRAWING SUBMITTAL REQUIREMENTS article.
- 3. Details on applicable field adjustments of lenses, louvers, or the complete fixture.
- 4. Construction or installation drawings, to scale, illustrating mounting procedures.

1.5 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

A. See Section 260100. Shop drawings shall include but not be limited to following:

- 1. General: For lighting fixtures and other equipment specified in this section, Contractor shall submit brochure indexed alphabetically in accordance with fixture identification tabbed for each type fixture. Submittals shall clearly identify catalog numbers and special features for each piece of equipment.

2. Fixture Submittals: Submittal of fixtures listed shall include the following:

a. Product Data Information:

- 1) Current manufacturer's product data sheet (copies are not acceptable) or construction drawing for each light fixture type. Duplication of types on a single data sheet or drawing is not acceptable.
- 2) Fixture dimensions, electrical ratings and weight.
- 3) Luminaire photometric test report issued by an approved independent testing laboratory. Tests shall have been conducted in accordance with recommended testing procedures of IES and include following information:
 - a) Manufacturer's name, catalog number and cut sheet.
 - b) Candlepower data, presented both graphically and numerically, in 10 degree increments (0, 5, 15, 25, etc.). Data shall be developed for both up and down light, normal, parallel, and at 22.5, 45 and 67.5 when light output is asymmetrical.
 - c) Zonal lumens stated numerically at 0-30, 0-40, 0-60, 0-90, and where applicable 90-120, 90-130, 0-180.
 - d) Coefficients of utilization in numerical form.
 - e) Total luminaire efficiency.
- 4) Fixture options, finishes, electrical characteristics, LED type, driver type and warranty, louver finish and cell quantity, lens thickness and type.
- 5) Batteries and warranty.

- 6) Manufacturer supplemental data sheets on all applicable accessories including but not limited to air handling data, wire guards; modular connection, pole base covers, etc.

b. Samples:

- 1) Provide when requested by Architect/Engineer, non-returnable sample fixture fitted with appropriate lamp, 120 volt components, and 6 ft. grounded power cord and plug.
- 2) Sample of Finishes: Submit chip samples for finishes and colors noted on lighting fixture schedule to be selected by Architect. Chip shall be minimum 4 inch square and shall be a true sample of finish with fixture material and not merely color. Submittal shall include complete description of finishing process.

1.6 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of lighting fixtures and equipment shall be provided in accordance with NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for grounding of exposed conductive parts of lighting fixtures and equipment using an equipment grounding conductor.

PART 2 - PRODUCTS

2.1 OUTDOOR LIGHTING FIXTURES

A. General:

1. Contractor shall provide mounting brackets, hardware, conduit, wire, boxes, and terminations required for complete installation.
2. Conduit connections shall be watertight. Conduit, boxes, brackets and hardware shall be corrosion-resistant type.
3. Access covers or lens frames shall be hinged on all fixtures mounted above 15 ft. Elements attached to covers or lens frames shall not slip or become loose upon opening of frame.
4. Outdoor fixtures shall have UL label marked "Suitable for Wet Locations."
5. Exposed screws located 15 ft. or less above grade on fixtures shall be tamperproof type.
6. Gasketing: All fixtures shall be gasketed. Gasketing shall be appropriately placed and be bonded to seal out water and insects. Gasket material shall withstand full range of operating temperatures without leaking, cracking or becoming loose. Gasket material shall be impervious to water and be made from neoprene, silicone or similar material. Gaskets shall be one continuous length unless otherwise indicated.
7. Photocontrol: Where fixtures are indicated to have integral photocontrol element, photocontrol shall be adjustable range of approximately 0.5 to 5.0 footcandles and shall be mounted in replaceable weatherproof, plug-in or twist lock assembly.

B. Materials and Applications:

1. Pole-Mounted Lighting Fixtures:
 - a. Driver shall be mounted on tray and be easily removable by loosening captive screws and plug-in wiring harness.
 - b. Floodlights: Floodlights with yokes or threaded stems shall be adjustable and have vertical aiming scales and repositioning stop.
2. Wall or Bracket-Mounted Lighting Fixtures: Brackets shall be designed to be attached to type fixture used and type wall or surface that fixtures are to be fastened.

3. Recessed, Surface or Pendant-Mounted Lighting Fixtures:

- a. Recessed mounting frames shall be designed to match type surface in which fixture is to be installed.
- b. Pendant mounting stems shall have canopies at attachment to junction box. Stems shall be designed to match fixture to which it is attached. Pendant-mounted lighting fixtures with integral ballasts shall be centerline loaded to ensure exact plumb.

C. Manufacturer: Manufacturer of outdoor lighting fixtures shall be as indicated on drawings and Lighting Fixture Schedule.

2.2 FUSING LIGHTING FIXTURES AND POLES

A. General:

1. Poles: Contractor shall provide both fuse holder and fuses for protection of smaller tap wiring run inside pole up to lighting fixtures.

B. Material and Application:

1. Fuse holder shall be one of following as appropriate:
 - a. Rated up to 600 volts for use on 120 volt, 277 volt or 480 volt outdoor mounted lighting fixtures. Fuse holders shall be waterproof type for 1-1/2 inch long x 13/32 inch diameter KTK or FNQ fuses and match wire size:
 - 1) Joy X8919 holder (two terminal)
 - 2) Joy X8917 holder (one terminal)
 - 3) Bussmann HEX holder (two terminal)
 - 4) Bussmann HEB holder (one terminal/insulating boots)
 - b. When manufacturer's standard design utilizes other fuse holders such as panel mounted (HPC-D, HPF or HPL-B), they will be acceptable providing voltage and ampacity for intended application does not exceed the values of those specified above.
2. Fuses: Fuses shall be provided for lighting fixtures in accordance with Section 264000, FUSES (TO 600 VOLTS) article.

C. Manufacturer: Fuse holders shall be manufactured by Bussmann Division of Cooper.

2.3 METAL LIGHTING POLES

A. General:

1. Contractor shall furnish and install poles for exterior lighting fixtures as indicated or specified in accordance with NEC 2002 Article 410.15.
2. Pole manufacturer shall provide:
 - a. Installation and handling instructions.
 - b. Template for placing anchor bolts and conduits.
 - c. Anchor bolts, nuts, washers, and bolt covers.
 - d. Touch-up finishing kit.
3. Pole along roadways shall meet the breakaway criteria of FHWA regulations July 1, 1990 and AASHTO-1985 "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals."
4. Shipping: Pole shall be covered with suitable wrapping or envelope for protection of finish for shipping via commercial carrier.

B. Materials and Applications:

1. Pole(s) shall be designed for winds up to 100 mph plus a 1.3 gust factor while supporting lighting fixtures of their projected surface areas.

2. Length of pole(s) shall be as indicated on drawings as appropriate.
3. Pole(s) shall be square non-tapered construction with handhole at base.
4. Construction shall be aluminum with aluminum baseplate. Each pole shall have accessible hand-hole with raintight cover and interior grounding lug of correct size for fastening of copper grounding conductor.
5. Shaft shall be minimum yield strength of 55,000 psi.
6. Top tenon of pole(s) shall match the fixture or mounting bracket slip-fitter.
7. Anchors and Hardware: Hot-rolled carbon steel anchor bolts with minimum yield strength of 50,000 psi shall be provided with each pole. Galvanized or plated bolts shall be sized and furnished by the pole manufacturer. Bolts shall have an "L" bend on one end for placement in concrete base and threads of adequate length on other end for bolting pole base in place. Each anchor bolt shall be provided with one leveling nut, one hold-down nut and two (2) washers by pole manufacturer. Nuts and washers shall be galvanized or plated. Leveling shims in lieu of leveling nuts will not be acceptable. Poles along roadways must have breakaway anchor bolt couplings.
8. Full base cover shall be provided to cover anchor bolts and pole baseplate. Base cover shall have provision for preventing vertical uplift of the cover after installation.
9. Accessories shall include but not be limited to following:
 - a. Mounting brackets
 - b. Arm connections and arms
 - c. Pole top cap
 - d. Pole base cover
10. Finish:
 - a. Poles shall be provided with factory finish coat to match luminaries. Poles specified with a finish coat shall also have prime coat. Finish coat of paint shall be carefully handled to avoid damaging the surface. Protective wrapping shall be applied prior to shipping. Protective wrapping shall be removed as soon as possible after unloading and be inspected for damage.
 - b. Poles with finished coat that are scraped or scratched shall be repaired as soon as possible to prevent rusting or oxidation. Scraped or scratched areas shall be finished in strict accordance, with manufacturer's instructions sanded, wiped clean and a new prime coat and finish coat applied. New finish coat shall match surrounding surfaces.

C. Manufacturers:

1. Aluminum poles shall be manufactured by Lexington Standard Corp. or J.H. Spalding, subsidiary of Kidde Inc.
2. Mortar grout shall be EMBECO No. 636 non-metallic by Master Builders or approved equal.

2.4 CONCRETE BASES FOR LIGHTING POLES (LESS THAN 50 FT.)

A. General:

1. Work specified shall consist of furnishing labor, equipment and services necessary for and reasonably incidental to construction of drilled piers.
2. Disposal of excess material from holes shall be as directed by Section 260500, EXCAVATION AND BACKFILL article.
3. Contractor shall familiarize himself with site conditions as represented by boring logs.
4. Drilled piers shall be installed by contractor experienced in such work. Pier excavations shall be performed with heavy-duty pier drilling rig. Equipment shall be maintained in satisfactory working condition and shall be operated by personnel with minimum 5 years experience.

B. Materials and Applications:

1. Concrete shall have a 28 day strength of at least 4000 psi and a maximum slump of 4 inch. Concrete shall not be used which has had water added to mix for more than one hour before placement. At least four (4) concrete test cylinder specimens shall be made from each day's pour. Testing laboratory approved by Architect/Engineer shall break two (2) of the cylinders at 7 days, break two (2) of the cylinders at 28 days and shall issue certified test reports.
2. Reinforcing Steel Bars: ASTM A615-90, Grade 60.
3. Anchor bolts, nuts, washers, and templates shall be supplied by pole manufacturer or supplier.

PART 3 - EXECUTION

3.1 OUTDOOR LIGHTING FIXTURE INSTALLATION

A. General:

1. Lighting fixtures shall be installed in accordance with NEC.
2. Fixtures shall be installed in strict accordance with manufacturer's instructions.
3. Contractor shall visually check each fixture housing for manufacturing flaws or misalignment of components such as gaskets, hinges or lenses. Fixtures shall also be inspected for cracks, holes or poor finish that will cause entry of moisture or insects, or cause rust to form thereby reducing the life of the housing.
4. Manufacturer shall replace leaking fixture housing or components without cost, if in opinion of Architect/Engineer such replacement is necessary to provide the required watertight integrity of the lighting fixture.

B. Wall or Bracket-Mounted Fixture Installation:

1. Contractor shall verify exact mounting location of fixtures with Architect to avoid interference with louvers, windows, doors and lintels. Where fixtures are indicated above doors or openings into building, they shall be centered on that door or opening.
2. Unless otherwise noted, all fixtures of same type on a single side of building shall be mounted in same horizontal plane.
3. Brackets shall be rigidly attached to building with appropriate hardware.

C. Recessed, Surface or Pendant-Mounted Fixture Installation:

1. Recessed fixture faceplate shall be pulled tight to mounting surface to prevent entry of insects. Fixtures shall be flush and square with surface.
2. Surface or pendant-mounted fixtures shall be rigidly attached to building or structure.
3. Pendant-mounted fixtures of same type below single canopy or covered walkway shall have bottom of fixture mounted at same horizontal plane unless walk below canopy or covered walkway slopes to match walk.

3.2 INSTALLATION OF FUSES IN LIGHTING FIXTURES AND POLES

- A. Fixture fuses shall be installed on line-side of ballast in each hot lead. Fuse holders in exterior fixtures shall be waterproof and have required terminals of size and type to match wiring. Fuse size and type (slow blow or quick blow) shall be as recommended by ballast manufacturer.
- B. Pole base fuse holder shall be installed in each hot lead of each circuit running to top of pole. Fuse size shall be as required to protect tap wiring run to top of pole. Fuse holder shall be located and be accessible through handhole in pole base.

3.3 METAL LIGHTING POLE INSTALLATION

- A. Concrete bases for poles shall comply with requirements of CONCRETE BASES FOR LIGHTING POLES article in this section of specifications.
- B. Top of concrete pole base shall be at height indicated on drawings.

- C. Underground wiring to poles shall be pulled in conduit. Conduit shall be Schedule 40 heavy wall PVC type, suitable for direct-burial under paved areas. Conduit shall be backfilled with sand and compacted.
- D. Provide one ground rod 3/4 inch x 10 ft. at base of each pole for grounding. Furnish and install No. 6 copper grounding conductor from ground rod to pole grounding lug. Ground wire shall be run in 1/2 inch PVC conduit. Connection at ground rod shall be either an exothermic weld or a wedge-locking device.
- E. Leveling nut must be screwed down on each anchor bolt until it meets the concrete; then they must be adjusted until they are level. Poles shall be set on concrete base after concrete has cured. Pole shall then be securely fastened to anchor bolts with top nuts in accordance with torque values provided by pole manufacturer.
- F. Contractor shall wire lighting fixtures to underground wiring and connect grounding conductor to grounding lug at each pole. Pole branch circuit wiring shall be tapped or spliced to main wiring run and run up in pole to lighting fixtures.
- G. Straightness: Poles shall be straight. Pole alignment shall be accomplished on calm and cloudy day or early in morning before solar radiation has expanded one side of pole causing thermal deflection. Alignment shall be in accordance with manufacturer's instructions.
- H. Solidly grout void that appears between the pole baseplate and the concrete pole base using non-shrinking mortar grout. A short piece of copper pipe shall be installed through the grout to pole interior to provide a drain. Exterior surfaces of poles shall be clean and free of concrete splash and stains.

3.4 INSTALLATION OF CONCRETE BASES FOR LIGHTING POLES (LESS THAN 50 FT.)

- A. Piers shall be machine drilled to shaft diameters, depths and locations as indicated on drawings.
- B. Any deviations from contract drawings in size and shape of pier shall be such that shaft at cut-off elevation is off center not more than 3 inch and shaft shall not be out of plumb more than 1 percent of its length.
- C. Excavation shall be advanced by any practical method, which would not adversely affect performance of completed piers or existing adjacent facilities. Pier excavations shall be maintained in an essentially dry condition by pumping, if necessary, until just prior to concreting.
- D. Loose earth falling into excavation must be removed immediately and completely prior to and during the placing of concrete.
- E. Conduct the work so that safety of workmen and the public is assured at all times. Open holes where finished concrete does not reach surface shall be barricaded, covered or otherwise protected continuously. No holes shall be left open overnight.
- F. Reinforcing Steel:
 - 1. Position reinforcement in accordance with placement plans.
 - 2. Maintain reinforcement securely in position in a manner that will hold reinforcing in place during concrete placement. Tie bars at intersections with soft steel wire.
 - 3. Metal reinforcement, just prior to time concrete is poured, shall be inspected and cleaned of flaky rust, mud, oil, ice, concrete splashing, or any other foreign material that could possibly destroy or reduce bond to concrete.
 - 4. After bars are tied in place, take whatever precautions are necessary to protect bars from damage by construction equipment or careless workmen. Damaged steel shall be replaced at no cost to Owner.
- G. Anchor Bolts: Anchor bolts shall be installed using plywood or steel template to ensure correct spacing and positioning to match final desired pole orientation. Care shall be taken to ensure that bolts remain plumb while concrete is being poured.

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Webster University
Cannon Design Project No. 004561.01**

- H. Power Conduits: Conduits shall extend a minimum of 3 ft. outside of concrete pier below grade and be capped. Insulated bushings shall be provided on conduits stubbed above pole base.
- I. Grounding: Metal poles shall be grounded with separate ground wire and ground rod. Ground wire shall be in 1/2 inch conduit run at right angles to power conduits. Conduit for ground wire shall extend a minimum of 2 ft. from pier below grade.
- J. Concrete:
 - 1. Concrete shall be placed after reinforcement steel anchor bolts and conduits are set.
 - 2. Piers shall be poured monolithically. However, if any pour is interrupted in such a manner as to allow the in-place concrete to set for more than one hour before pour is resumed, surface of the in-place concrete shall be leveled. Just before concreting is resumed, all laitance shall be cleaned from existing surface and surface roughened and slushed with a 1:1 cement grout.
 - 3. Fresh concrete, after placing, shall be kept at a minimum temperature of 50 deg. F. for the first 72 hours and kept at a temperature above freezing for the next 72 hours. Use of salt or chemical to prevent freezing will not be permitted.
 - 4. Conform to recommendations in ACI 306.
 - 5. Concrete damaged by freezing shall be removed and replaced under this section of specification at no additional cost to Owner.

3.5 LIGHTING FIXTURE SCHEDULE

- A. See Lighting Fixture Schedule on drawings.

END OF SECTION 265200

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 265700 – LIGHTING CONTROL EQUIPMENT

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
1.7	GROUNDING AND BONDING SYSTEMS	2
PART 2 - PRODUCTS		2
2.1	MISCELLANEOUS LIGHTING CONTROL DEVICES	2
2.2	UNIFIED BUILDING LIGHTING CONTROL SYSTEM	3
2.3	OCCUPANCY SENSORS	12
PART 3 - EXECUTION		13
3.1	INSTALLATION OF MISCELLANEOUS LIGHTING CONTROL DEVICES	13
3.2	INSTALLATION OF UNIFIED BUILDING LIGHTING CONTROL SYSTEM	14
3.3	INSTALLATION OF OCCUPANCY SENSORS	15

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SECTION 265700 - LIGHTING CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL REQUIREMENTS

- A. This section is intended to cover lighting control equipment and devices and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Outdoor and Wet Locations: Where the term outdoor is used in this section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- E. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.
- F. Record Drawings: Maintain record drawings for all lighting branch circuits controlled by remote control devices or equipment to be provided by this section of specifications.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install the following lighting control equipment:
 - 1. Unified Building Lighting Control System
 - 2. Occupancy Sensors

1.4 DESCRIPTION OF SYSTEMS

- A. Lighting control equipment and devices shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Specification Compliance: Submit a line-by-line comparison that describes the differences between each specification requirement and the device, equipment or systems being proposed. Comparison shall include a complete listing of how the proposed device, equipment or systems differ from that specified with regard to size, quantity, quality, method of control, features and functions, and installation requirements.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.

B. Shop drawing submittals shall include but not be limited to the following:

1. Unified Building Lighting Control System:

- a. Bill of Material (BOM) list with item references
- b. Product data sheet for each item listed on the Bill of Material
- c. Communications riser diagram shall indicate the MAC address and BACnet Device ID for each BACnet native lighting controller that is part of the Unified Lighting Control System. The riser diagram shall also include the location and part number of each BACnet native lighting controller, and each BAS BACnet router.
- d. Panel and controller schedules shall indicate the circuit number, area description, and control sequence designation for each output.
- e. Written Sequence of Operation and BACnet Points List for each required Sequence of Operation
- f. Point-to-point wiring details for all inputs and outputs shall indicate the wiring and terminations.
- g. Addressable satellite and station network diagram for each lighting controller. The network diagram shall indicate the devices physical address, part number and location designation. The location designation shall include the lighting controllers BACnet Device ID, room number, switch box designation, and gang position.
- h. Typical wiring diagrams for all items listed on the Bill of Material
- i. Dimensional drawings of all items listed on the Bill of Material.
- j. Written control sequences for each sequence of operation required.
- k. Specification compliance statement.

2. Standalone Occupancy Sensors:

- a. Cut Sheet Package: Submit current manufacturer's data sheets for all sensors and related accessories for approval.
- b. Full Size Drawings: Submit full size reflected ceiling plans for approval, indicating:
 - 1) Sensor locations, types, and mounting information.
 - 2) Associated "switch packs" and "power packs".
 - 3) Major and minor motion coverage patterns for equipped technologies. Coverage patterns shall be color-coded for clarity.
 - 4) Sensor frequencies (where multiple frequencies are used to eliminate interference).
 - 5) Light fixtures, HVAC air devices, and furniture layout.
 - 6) Sensor legend to identify sensor types.
 - 7) Title block from company developing full sized drawings.

1.7 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with NEC.
- B. Reference Section 264500 - GROUNDING AND BONDING for grounding of metallic enclosures and conduit.

PART 2 - PRODUCTS

2.1 MISCELLANEOUS LIGHTING CONTROL DEVICES

A. General:

1. Reference: Miscellaneous lighting control devices shall be of type shown and as specified. Devices shall be UL listed.
2. Complete Part Numbers: Listed manufacturer's part numbers in tables are to establish a type and standard of quality. Prefix and/or suffix, whether to be added or deleted to complete number, shall be Contractor's responsibility. This applies specifically but not exclusively to color identification, grade and compliance with standards and

specifications. Addition or deletion of prefix or suffix to change device to lower grade will not be acceptable.

3. Color: Verify color of devices with Architect prior to installation.
4. Device Grounding: Device shall have self-grounding feature via grounding clip or supporting screw as specified. Clip shall ensure ground continuity between mounting strap and metal wall box. Devices that have grounding terminal shall have grounding conductor properly terminated.
5. Manufacturer: Devices shall be by single manufacturer unless noted otherwise or where they are not commercially available.
6. Sound Isolation: Reference Section 261300, OUTLET AND SWITCH BOXES article Indoor Box Material and Application subparagraph for sound isolation of raceways run to device boxes on opposite sides of walls.

B. Miscellaneous Devices:

1. Electronic Time Switch: Programmable electronic digital time switch with back-lit LCD display shall be rated for dual voltage 120/277 volts and be good for 800/1200 watts. Switches shall be SPST or SPDT as indicated on drawings. Switches shall have an adjustable time delay from 5 minutes to 12 hours. Switches shall be gangable and have 3 year warranty. Switches shall be "The Watt Stopper" (IntellSwitch).
2. LED 120/277 Volt Dimmer, Slide Type:
 - a. Dimmers shall be Architectural Specification 8 amp type for 120/277 volt circuits and be UL listed. Dimmers shall be full-range type providing an increase in lighting level from off to full light.
 - b. Dimmer switches shall be 0-10 volt linear slide control type with cover plate of finish selected by Architect.
 - c. Units shall be mounted in accordance with manufacturer's instructions for proper dissipation of heat and loading.
 - d. Units shall be "NOVA-T" as manufactured by Lutron Electronic Co. Inc.

2.2 UNIFIED BUILDING LIGHTING CONTROL SYSTEM

A. System Description:

1. Unified Lighting Control System shall consist of BACnet native lighting controllers, Centralized Panels and/or Distributed Controllers, which reside on the BACnet MS/TP network of the Building Automation System (BAS). The Unified Lighting Control System shall be an integral part of the BAS such that the operator experiences one unified system of controlling, monitoring, scheduling, trending, alarming, etc.
2. Unified Lighting Control System shall also consist of Satellites and low voltage field devices such as; Stations, occupancy sensors, wall switches, and light level sensors.
3. Unified Lighting Control System shall directly control the lighting as specified in the Lighting Controls Sequence of Operations shown on plans.

B. Scope of Work:

1. Provide all components of the Unified Lighting Control System as required to comply with Sequence of Operations, plans, and specifications. These components shall consist of Centralized Panels, Distributed Controllers, Satellites, and low voltage field devices such as Stations, occupancy sensors, wall switches, and light level sensors.
2. Provide all labor to install the Unified Lighting Control System and provide all of the required materials (conduit, raceways, wire, etc.) and make all of the line and low voltage wiring terminations for a complete and operable Lighting Control System which functions properly and in accordance with the specifications and drawings.
3. The Unified Lighting Control System shall be programmed by the BAS Controls Contractor (ACES). Coordinate installation and programming with BAS Controls Contractor.
4. Prior to bid, contractor shall request a copy of the manufacturer's contractor responsibility guide matrix and coordinate scope responsibilities with BAS Controls Contractor (ACES).

C. Related Sections:

1. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
2. The following sections constitute related work:
 - a. SECTION 239500 – CONTROLS AND INSTRUMENTATION

D. Quality Assurance:

1. BAS Controls Contractor Qualifications:
 - a. Contractor shall be an authorized dealer for the Unified Lighting Control System manufacturer products furnished.
 - b. Contractor shall have an established office with experienced engineering and service personnel within a fifty (50) mile radius of the project site.
 - c. Contractor shall have successfully completed the manufacturer's Technical Certification Training.
 - 1) Upon request, BAS Controls Contractor shall present record of completed training including course outlines and dated certificate.
 - d. Contractor shall have a minimum five (5) years of experience integrating lighting control systems with BACnet Building Automation Systems.
 - e. Manufacturer shall have an established lighting control business that has been in continuous operation for more than 15 years.
 - f. Manufacturer shall have a minimum of five (5) years of experience designing and manufacturing BACnet native lighting controls.
 - g. Manufacturer shall provide, via web download, free firmware and driver files during the warranty period.

E. Codes and Standards: Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Energy Conservation Code (IECC)
4. National Electrical Manufacturer Association (NEMA)
5. ANSI/ASHRAE 135-2010 Rev 12: Data Communication Protocol for Building Automation and Control Systems (BACNET)
6. Underwriters Laboratory (UL) – UL916 Energy Management, UL508 Industrial Control Equipment, and UL924 Emergency Lighting and Power Equipment.

F. As-Built Drawings:

1. Contractor shall provide as-built drawings including:
 - a. Updated submittal drawings reflecting the actual installation of the system.
 - b. Installation guides and user guides for each item list on the Bill of Material
 - c. Operating and maintenance data.

G. Warranty:

1. Manufacturer shall provide 24 month labor and material warranty on the complete Unified Lighting Control System. Warranty shall include all Centralized Panels, Distributed Controllers, Satellites and low voltage field devices such as Stations, occupancy sensors, wall switches, and light level sensors. If within twenty four (24) months from the date of acceptance of the Unified Lighting Control System, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the Contractor.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

2. Manufacturer shall provide a 24 month parts only warranty on the components provided. The warranty period shall commence after written owner acceptance and full payment is received by the Manufacturer. If within 24 months from the date of acceptance of the Unified Lighting Control System, upon written notice from the Contractor, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the Manufacturer.

H. Approved Products and Suppliers:

1. Basis of design is Unified Lighting Control System by Blue Ridge Technologies, Marietta GA (800-241-9173), and shall be furnished to the contractor by ACES.
2. Approved Manufacturer and BAS Controls Contractor:

Manufacturer	BAS Controls Contractor
Blue Ridge Technologies	ACES

3. All proposed substitutions must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date. Submitted substitutions must be accompanied by a review of the specification noting compliance on a line-by-line basis.
4. Contractor utilizing substitutions accept full responsibility for any associated costs directly related to substitution including but not limited to; required modifications to circuitry, devices, and wiring.

I. Bid Alternate:

1. Provide Watt Stopper DLM or Acuity N-Light lighting control system in-lieu of Blue Ridge Lighting Control system.
 - a. Alternate lighting control system shall NOT be unified with the mechanical BAS System, but shall be tied to the BAS via a BACnet gateway.
 - b. Alternate lighting control system shall not be furnished to the contractor or programmed by ACES.
 - c. Alternate lighting control system shall include general requirements for Unified Lighting Control System including shop drawings, as-built drawings, as well as start-up, programming, and training requirements as indicted in Section 3.2, Installation of Unified Building Lighting Control System.
 - d. Alternate lighting control system shall be configured to include the device requirements shown on plans.
 - e. Alternate lighting control system shall be programmed by factory trained technician to meet the control requirements indicated in the sequence of operations.
 - f. For the bid alternate, BAS Controls Contractor shall program the BAS system to include all scheduling functions indicated on sequence of operations, to allow those schedules to be triggered from the BAS system. Alternate lighting control system shall be programmed by factory technician to accept the scheduling commands from the BAS system.
 - g. For the bid alternate, BAS Controls Contractor shall program the BAS system to include Division 23 demand ventilation requirements utilizing Division 26 occupancy sensors. Alternate lighting control system factory technician shall assist BAS system contractor with system integration efforts.
2. Contractor shall include all costs in alternate bid, related to proving a complete and operable alternate lighting control system, including BAS system integration costs from BAS system contractor.

J. Materials:

1. Provide new products the manufacturer is currently manufacturing and selling for use in new installations.
2. Manufacturer shall offer spare or equivalent parts for at least two years after completion of this contract. Spare parts include:

- a. Relays.
 - b. Electronics.
 - c. Transformers.
 - d. Low Voltage Field Devices such as addressable stations, occupancy sensors, wall switches, and light level sensors
 3. Manufacturer shall offer repair services or replacement parts for at least 2 years after shipment.
- K. Operator Interface:
1. Refer to Division 23 Section 239500 – CONTROLS AND INSTRUMENTATION.
 2. The Operator Interface furnished shall be the primary operator interface for the Unified Lighting Control System.
 3. All necessary operator functions, including scheduling, reporting, monitoring, overriding, etc., shall be provided through the Building Automation System operator workstations.
 4. Lighting floor plan graphics for switched lighting zones shall utilize the color grey to represent Off, and the color white to represent On.
 5. Dimmed lighting zones shall also utilize a numerical value (percentage) to represent the lighting intensity.
- L. Centralized Panel:
1. Contractor shall provide Centralized Panels as detailed on drawings, and approved shop drawings.
 2. Panel shall include the BACnet native lighting controller, relays, transformer, voltage barriers, and other panel components.
 3. Enclosure shall be manufactured with a minimum of 16 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
 4. Interior shall be manufactured with a minimum of 18 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated.
 5. Panel shall be provided with control power transformer; 120VAC or 277VAC, 30VA, 50/60hz.
 - a. Control power transformer shall be an inherently limited.
 - b. Optional 347VAC control power transformer shall be available as required.
 6. Panel shall be available in 08, 16, 32, 48, and 64 relay capacities, and shall accept any relay quantity between 1 and the maximum capacity of the panel.
 7. Panel shall provide an odd/even relay number orientation that matches the layout of a standard circuit breaker panel.
 8. Panel shall be provided with separate low voltage and line voltage compartments.
 - a. Low voltage compartment, 16 relay capacity and greater, shall be accessed through a hinged door with a key.
 - b. Low voltage compartment, 08 relay capacity, shall be accessed through a screw-on cover.
 - c. Access to the low voltage compartment (controller and low voltage terminations) shall not expose service personnel to the line voltage compartment, wiring, or terminations.
 - d. The line voltage compartment shall be accessed by removing dead-front cover.
 - e. Dead-front cover and line voltage compartments shall be properly marked.
 - f. Panels without dead-front covers are not acceptable.
 - g. Relay blanks shall be provided for each unpopulated relay slot in order to maintain proper voltage separation.
 9. Panels, 16 relay capacity or greater, shall support optional relay voltage barriers to separate normal and emergency powered relays or to comply with other code requirements.
 - a. Voltage barriers shall not reduce the relay capacity of the panel.

- b. Panels equipped for UL924 shall include voltage barriers and the UL924 section shall be properly marked.
 - 10. Enclosure, 08 relay capacity, shall be provided with a screw on cover.
 - 11. Enclosure, 16 relay capacity or greater;
 - a. Shall be provided with a hinged, lockable door. The hinged, lockable door shall be reversible in the field to allow left or right swing.
 - b. Shall be available for rough-in
 - c. Shall be provided with threaded studs for mounting the interior.
 - d. Shall be available with optional flush doors for recess mounting.
 - 12. Relay shall be a UL Listed component with a minimum Short Circuit Current Rating (SCCR) of 30,000 amps at 277VAC
 - 13. Relay shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - a. Electrically held or electrically latched relays are not acceptable
 - b. HOA switch on relays are not acceptable.
 - 14. Relay shall be rated for the following load ratings:
 - a. Maximum of 20 amp Tungsten at 347VAC
 - b. Maximum of 30 amp Ballast at 347VAC
 - c. Maximum of 20 amp Resistive at 347VAC
 - d. 1.5 Horse Power at 120VAC
 - 15. Relay shall be individually replaceable and shall directly connect to the relay interface board without soldering.
 - 16. Relay shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.
- M. Distributed Controller:
- 1. Contractor shall provide Distributed Controllers as detailed on drawings, and approved shop drawings.
 - 2. Distributed Controller shall include the BACnet native lighting controller, relays, transformer, voltage barriers, and other components.
 - 3. Distributed Controller shall be manufactured with a minimum of 20 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
 - 4. Distributed Controller shall be provided with integral power supply feed by 120VAC-277VAC, 50/60hz.
 - a. Controllers that require external transformer or power supply are not acceptable.
 - b. Optional 347VAC shall be available as required.
 - 5. Distributed Controller shall be plenum rated and shall mount to 4 inch square or 4-11/16 inch junction box.
 - 6. Relay shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - a. Electrically held or electrically latched relays are not acceptable.
 - b. HOA switch on relays are not acceptable.
 - 7. Relays shall be rated for the following load ratings:
 - a. Maximum of 20 amp Tungsten at 120VAC
 - b. Maximum of 20 amp Ballast at 277VAC
 - c. Maximum of 20 amp Resistive at 277VAC
 - d. 2 Horse Power at 120VAC
 - e. Relays with load ratings below 20 amps are not acceptable.

8. Relay shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.

N. BACnet Native Lighting Controllers (BNLC):

1. BACnet Native Lighting Controllers (BNLC) inside Centralized Panels and Distributed Controllers shall be BACnet Advanced Application Controller (B-AAC) in accordance with BACnet Standardized Device Profile (Annex L), and shall comply with BACnet Protocol Revision 135-2010 Rev 12.
2. BNLC shall be provided with BACnet MS/TP network communications.
3. BNLC shall be provided with a micro-USB port for temporary connection to a laptop computer for product configuration.
 - a. Connection shall support memory downloads, firmware upgrades and troubleshooting operations.
 - b. Controller that requires proprietary cables are not acceptable.
4. BNLC shall have the capability to read and write values to other BACnet controllers on the Building Automation System (BAS) BACnet MS/TP network.
 - a. Control variables used to integrate control strategies across multiple BACnet controllers shall be readable by each BACnet controller on the network.
5. BNLC shall have a real-time clock and shall utilize BACnet Universal Time Synchronization service.
6. BNLC shall support all of the following BACnet Interoperability Building Blocks (BIBBs):
 - a. Data Sharing – Read Property-B (DS-RP-B)
 - b. Data Sharing – Read Property Multiple-A (DS-RPM-B)
 - c. Data Sharing – Write Property-B (DS-WP-B)
 - d. Data Sharing – Write Property Multiple-B (DS-WPM-B)
 - e. Data Sharing – Change of Value-B (DS-COV-B)
 - f. Data Sharing – Change of Value Unsolicited-B (DS-COVU-B)
 - g. Scheduling – Internal-B (SCHED-I-B)
 - h. Alarm and Event – Notification-Internal-B (AE-N-I-B)
 - i. Alarm and Event – ACK-B (AE-ACK-B)
 - j. Alarm and Event – Information-B (AE-INFO-B)
 - k. Data Management – Dynamic Device Binding (DM-DDB-B)
 - l. Data Management – Dynamic Object Binding (DM-DOB-B)
 - m. Data Management – Device Communication Control (DM-DCC-B)
 - n. Data Management – Time Synchronization (DM-TS-B)
 - o. Data Management – UTC Time Synchronization (DM-UTC-B)
7. BNLC shall provide a means to field select any one of the following BACnet baud rates; 9.6k, 19.2k, 38.4k, 76.8k or 115.2K.
8. BNLC shall provide a means to field select the MAC address and shall have a range from 1 to 127.
9. BNLC shall auto generate a BACnet Device ID that is based upon the selected MAC address and the manufacturer's BACnet Vendor ID.
 - a. BNLC shall also be capable of being assigned a custom BACnet Device ID. The custom BACnet Device ID is assignable by the Building Automation System within the limits of the BACnet standard with a maximum value of 4,194,303.
10. BNLC shall be provided with a subnet port for optional Satellites and Stations.
 - a. Subnet shall be free-topology network (stars and t-taps allowed).
 - b. Systems requiring option cards are not acceptable.

O. Low Voltage Inputs and Outputs:

1. Centralized Panels, Distributed Controllers, and Satellites shall be provided with Universal Inputs (UI).
 - a. UI shall be provided for direct connection to low voltage field devices such as dry contact switches, occupancy sensors, and light level sensors.
 - b. Provide a minimum of:
 - 1) Twenty-four (24) each for Centralized Panels
 - 2) Six (6) each for Distributed Controllers
 - 3) Six (6) each for Satellites
2. UI shall be field configurable as either a digital input or an analog input.
 - a. Digital input shall be compatible with dry contact switches or occupancy sensors.
 - b. Analog input shall be compatible with either 0-5VDC, 0-10VDC, or 4-20ma
3. Centralized Panels, Distributed Controller, and Satellite shall be provided with an integral 24VDC, 200ma supply for powering 24VDC field devices connected to Universal Inputs (UI), or addressable stations connected to the subnet.
4. Distributed Controllers, and Satellites equipped with optional 0-10VDC dimming capability shall be provided with Analog Outputs (AO).
 - a. AO shall be provided for direct connection to 0-10VDC dimming ballasts (Advance Mark 7 or equal).
 - b. Provide a minimum of;
 - 1) Two (2) each for Distributed Controllers
 - 2) Two (2) each for Satellites
 - c. AO shall be capable of sinking up to 100ma, each
 - d. AO shall be compatible with 0-10VDC dimming ballasts that comply with IEC 60929 Annex E, Section E.2.
5. Distributed Controllers and Satellites shall be provided with two (2) line voltage switch inputs inside the line voltage compartment for use with line voltage wall switches or occupancy sensors.
 - a. Line voltage switch input shall be field configurable as either a maintained or state change input.

P. Satellite:

1. Contractor shall provide Satellites as detailed on drawings, and approved shop drawings.
2. Satellite shall reside on the subnet of Centralized Panels and Distributed Controllers, and shall include the controller, relays, transformer, voltage barriers, and other components.
3. Satellite shall be manufactured with a minimum of 20 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
4. Satellite shall be provided with integral power supply feed by 120VAC-277VAC, 50/60hz.
 - a. Satellites that require an external transformer or power supply are not acceptable.
 - b. Optional 347VAC shall be available as required.
5. Satellite shall be plenum rated and shall mount to 4" square or 4 11/16" junction box.
6. Satellite relays shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - a. Electrically held or electrically latched relays are not acceptable.
 - b. HOA switch on relays are not acceptable.
7. Relays shall be rated for the following load ratings:
 - a. Maximum of 20 amp Tungsten at 120VAC
 - b. Maximum of 20 amp Ballast at 277VAC

- c. Maximum of 20 amp Resistive at 277VAC
 - d. 2.0 Horse Power at 120VAC
 - e. Relays with load ratings below 20 amps are not acceptable.
8. Relays shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.
9. Satellite shall provide a means to field select the slot address.
- a. Up to 8 slots for Centralized Panels
 - b. Up to 7 slots for Distributed Controllers

Q. Low Voltage Stations:

- 1. Contractor shall provide Stations as detailed on drawings, and approved shop drawings.
- 2. Stations shall be gang-able with other low voltage, decorator style devices under a common face plate.
- 3. Stations shall reside on a four (4) wire network (CL3P 22/4); two (2) for digital communication and two (2) for 24VDC power.
- 4. Stations shall be available in the following configurations:
 - a. Channel On/Off - one (1), two (2), three (3), four (4), or six (6) button
 - b. Channel Raise/Lower - one (1), or two (2) channels
 - c. Preset – three (3) preset with raise/lower, or six (6) preset
- 5. Stations shall be provided with LED indicator for status. LED On = Active or ON, LED Off = Inactive or OFF. LED shall also serve as a locator light by operating a low level that is visible in a dark room. LED shall also be capable of blinking during the blink warning period.
- 6. Stations shall utilize capacitive touch technology.
 - a. Stations with mechanical switches or moving parts are not acceptable.
- 7. Stations shall be available in white, black, grey, or light almond colors.
- 8. Stations utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.

R. Low Voltage Occupancy Sensors:

- 1. Contractor shall provide Occupancy Sensors as detailed on drawings, and approved shop drawings.
- 2. Occupancy Sensors shall sense the presence of human activity within the desired space and provide a signal to the controller. The controller programming shall determine the on, off or dimming signals required to perform the sequences of operation.
- 3. Occupancy Sensors shall utilize passive infrared (PIR) technology to detect occupant motion.
- 4. For applications where a second method of sensing is necessary to adequately detect or maintain occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
- 5. Acceptable dual technology includes;
 - a. PIR/Microphonics (also known as Passive Dual Technology or PDT)
 - b. PIR/Ultrasonic
- 6. All sensing technologies provided shall not interfere with other electronic devices within the space (such as electronic white board readers or hearing aids). Microwave based sensing technologies are not acceptable for use within the building envelope.
- 7. Occupancy Sensors shall be 24VDC with three (3) wire (common, power, and signal), or four (4) wire (common, power, signal common, and signal) connections and shall be available for the following applications:
 - a. Type A Ceiling Mount Passive Infrared – OSCM-9-R or equal
 - b. Type B Ceiling Mount Passive Dual Tech – OSCM-PDT-9-R or equal

- c. Type C Wall Mount Passive Infrared – OSWV-16-R or equal
 - d. Type D Wall Mount Passive Dual Tech – OSWV-PDT-R or equal
 - e. Hallway Passive Infrared – OSHW-13-R or equal
- 8. Occupancy Sensors with automatic time delay adjustments are not acceptable. The controller shall determine the occupancy sensor time delay, minimum on time or other timing parameters.
- 9. Occupancy sensors shall have a minimum timer value of 30 seconds or less.
- 10. Occupancy Sensor shall be factory calibrated for optimum performance for its installed PIR lens, and shall not require initial or subsequent field adjustment of detection sensitivity.
- 11. Occupancy Sensors with integral light sensor are not acceptable.
- 12. Occupancy Sensors utilizing pre-manufactured cables or proprietary wiring to connect to controller are not acceptable.
- S. Low Voltage Wall Switches:
 - 1. Contractor shall provide Wall Switches as detailed on drawings.
 - 2. Wall Switches shall be gang-able with other low voltage, decorator style devices under a common face plate.
 - 3. Wall Switches utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.
- T. Low Voltage Light Level Sensors:
 - 1. Contractor shall provide low voltage Light Level Sensors as detailed on drawings.
 - 2. Light Level Sensors shall be a 3 wire (common, power and signal) analog, linear photo diode and shall be available for the following applications:
 - a. Indoor, 0-100 FC, 0-50FC, or 0-25FC
 - b. Outdoor, 0 - 250FC, 0-50FC, or 0-25FC
 - c. Atrium, 0 - 1,000FC
 - d. Skylight, 0 - 2,000FC
 - 3. Light Levels Sensors that require an interface box, manual set points, or external power source are not acceptable.
 - 4. Light Level Sensors utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.
- U. Line Voltage Occupancy:
 - 1. Contractor shall provide line voltage occupancy sensors that are directly connected to the Unified Lighting Control System.
 - 2. Refer to OCCUPANCY SENSOR article for standalone line voltage occupancy sensors that are not part of the Unified Building Lighting Control System.
- V. Technicians Kit:
 - 1. Contractor shall provide Technicians Kit to owner during training. The Technicians Kit shall include:
 - a. Configuration software on USB flash drive
 - b. USB Cable (micro-B)
 - c. Bluetooth USB Dongle
 - d. Bluetooth Module
 - 2. Contractors shall provide an electronic copy of all system files and firmware images for all BACnet Native Lighting Controllers (BNLC).
 - 3. Configuration software shall be capable of local communication with one or multiple BNLC using USB (or optional Bluetooth). Upon local connection with one BNLC the software shall be capable of communication with any other BNLC on that BACnet MSTP segment/LAN.

4. Configuration software shall be capable of remote communication with one or multiple BNLC using IP connection through the BACnet IP/MSTP router (BACnet router must support tunneling). Upon remote connection with one BNLC the software shall be capable of communication with any other BNLC on that BACnet MSTP segment/LAN.
5. Configuration software shall be capable of setting or changing all BNLC parameters.

2.3 OCCUPANCY SENSORS

A. General:

1. Contractor shall modify occupancy sensor layouts in the field, as required to comply with requirements in PART 3 – EXECUTION.
2. Contractor shall furnish and install a complete and operable occupancy sensing lighting control system as part of the “Unified Building Lighting Control System” and as standalone lighting control systems for stand alone spaces. Refer to plans and Sequence of Operations to determine where standalone sensors occur and where sensors are tied to a larger lighting control system.
3. Contractor shall install all low-voltage and line-voltage wiring, and all relays and power supplies required for system operation.

B. Quality Assurance:

1. Product manufacturer shall have a minimum of 5 years experience in the manufacturing of occupancy sensors.
2. All components shall be UL listed, meet all state and local applicable code requirements.
3. All components shall offer a 5 year manufacturer's warranty.

C. Warranty and Service Contract: The manufacturer shall provide a full 5 year limited warranty on all equipment supplied. Warranty shall cover the repair or replacement, of any equipment found to be defective, upon authorized equipment return to manufacturer.

D. Maintenance: The manufacturer must make available new replacement parts for a minimum period of 10 years from the final date of commissioning.

E. System and Materials:

1. System Features for All Sensors:
 - a. Sensors shall be equipped with relay contacts and power supplies as required to switch loads.
 - b. Sensors shall contain “sensitivity” controls to adapt to room size and eliminate false triggering by HVAC.
 - c. Sensor electronics shall be replaceable, in the event of failure, without disturbing hard-wiring or sensor mounting.
 - d. Sensors shall avoid hearing aid frequencies. Where interferences occur, Contractor shall modify system to eliminate interference.
 - e. Line voltage wall switch sensors shall be compatible with magnetic and electronic ballasts, shall be equipped with high capacity relay contacts with ratings that include tungsten loads.
 - f. Where specified, the occupancy sensor system shall be capable of interfacing with EMS, BAS, HVAC and other controllers by providing an isolated relay with normally open, normally closed and common outputs.
 - g. All sensors shall have a manual override switch to allow the load(s) to be turned on without the use of tools in the event of sensor malfunction.
 - h. All sensors shall be provided with an indicator light to verify that motion is being detected and that the unit is in operation.
 - i. Transformer relays (“power packs” and “switch packs”) shall have a minimum rating of 1500 watts at 120 volts for an incandescent load or 4000 watts at 277 VAC for a ballast load.
 - j. Sensors shall have minimum adjustable 30 seconds to 30 minutes time delay and sensitivity adjustment.

2. Additional Features for Dual Technology Sensors:
 - a. Sensors shall incorporate separate, concurrent time delays.
 - b. Sensors shall provide a 10 second "grace period" that allows lights to be turned on by motion anywhere in a room after they are turned off due to inactivity.
3. System Performance:
 - a. Unless otherwise indicated, Contractor shall install a sensor system capable of detecting minor types of motion, as defined by NEMA WD-7 (i.e. picking up a telephone, turning a page in a book) anywhere in the space.
 - b. In lobbies and corridors indicated to have occupancy sensor control, Contractor shall install a sensor system capable of detecting major motion, as defined by NEMA WD-7 (i.e. walking motion) anywhere in the space.
4. Manufacturer: The listing of any manufacturer as "acceptable" does not imply automatic approval. It is the sole responsibility of the Electrical Contractor to ensure that any price quotations received and submittals made are for systems that meet or exceed these specifications. System design is based on products manufactured by Acuity Sensor Switch or N-Light. Additional acceptable manufacturers shall be Blue Ridge Technologies.
5. Sensor Types:

Type	Series	Mounting	Mtg. Height	Technology	Angle, Coverage	Features
1PIR	WSX-D-SA	Wall Switch	See 260100	PIR	180°, 300 ft ²	a,b
A	CM 9	Ceiling	8' to 15'	PIR	360°, 500 ft ²	c
B	CM PDT 9	Ceiling	8' to 15'	Dual Tech	360°, 500 ft ²	c
C	WV 16	Ceiling	8' to 10'	PIR	120°, 950 ft ²	c
D	WV PDT 16	Ceiling	8' to 10'	Dual Tech	120°, 950 ft ²	c

- a. Integral relay.
- b. Four wire; hot, neutral, and 0-10 volt dimming output.
- c. In stand-alone configuration, provide sensor equipped with isolated auxiliary relay.

PART 3 - EXECUTION

3.1 INSTALLATION OF MISCELLANEOUS LIGHTING CONTROL DEVICES

- A. General: After wiring has been installed, mount wiring devices in clean outlet boxes as indicated. Wiring shall be terminated correctly and adequately tightened. Damaged or inoperative wiring devices shall be replaced as necessary.
- B. Device Mounting and Location:
 1. Devices shall not be mounted back-to-back on opposite sides of the same wall or partition. Through-the-wall boxes are not permitted. Where they are shown back-to-back on the drawings, they shall be staggered by at least 6 inch or be mounted below the devices on the other side of the wall.
 2. Devices shall not be mounted on centerline of structural column but be located to one side to permit the accessibility to the device should a future wall or partition be placed on centerline of column. When devices are shown on centerline of column on drawings, they shall be located to left or right of column centerline as directed by Architect/Engineer.
- C. LED dimmers shall be mounted vertically. Where dimmers are ganged they shall be derated in accordance with manufacturer's instruction.

3.2 INSTALLATION OF UNIFIED BUILDING LIGHTING CONTROL SYSTEM

A. Programming and Configuration:

1. Contractor under this Section shall program and configure Unified Lighting Control System controllers to perform the functions in the Lighting Controls Sequence of Operations shown on plans.
2. Contractor/manufacturer shall meet with Owner and Engineer to review the sequence of operations and identify any additional data required prior to programming lighting control system.
3. Contractor shall configure the Unified Lighting Control System to be an integral part of the Building Automation System such that the operator experiences one unified system of controlling, monitoring, scheduling, trending, alarming, etc.
4. Contractor shall provide an operator interface that includes the following graphics:
 - a. Floor Plan Graphic: Each controlled zone shall be represented on a Floor Plan Graphic. The status shall be represented on the graphic through the use of color.
 - 1) Grey shall represent Off.
 - 2) White shall represent On.
 - 3) Areas with dimming, multiple levels or presets shall also have an adjacent numeric value showing the current percentage or active preset.
 - b. Zone Detail Graphic. Each zone shall have a Zone Detail Graphic displaying the following:
 - 1) Status of channel(s) associated with the Zone. Status shall be represented on the graphic through the use of color.
 - 2) Status of channel timer values for override switches or occupancy sensors associated with the channel. The time-out value shall be represented in minutes and seconds.
 - 3) Status of channel runtime and cycle count. The runtime shall be represented in hours and minutes. The cycle count shall be represented as a numeric value.
5. Provided that the operator has the appropriate access, each Zone shall be able to be commanded from the Floor Plan Graphic.

B. Control System Checkout and Testing: Contractor shall complete startup testing to verify operational control system before notifying Owner of system demonstration.

1. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
2. Verify that control wiring is properly connected.
3. Validate that wiring is free of shorts and ground faults, and that terminations are tight.
4. Verify that system performs the functions in the Lighting Controls Sequence of Operations shown on plans.
5. Simulate and observe each operational mode by overriding and varying inputs and schedules.
6. Check each alarm with an appropriate signal at a value that will trip the alarm.
7. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.

C. Control System Demonstration and Acceptance:

1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved.

- D. Training: Contractor shall provide two (2) four (4) hour sessions of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the Unified Lighting Control System software, layout and naming conventions, and a walk through of the facility with the facility manager to identify Centralized Panels, Distributed Controllers, Satellite Controllers, and low voltage field devices and locations.
- E. Return Visit: Six months after project completion, Contractor and factory certified engineer shall meet with the Owner to provide additional training to staff, verify system is operating correctly, and make any program changes or repairs as needed. Manufacturer shall document programming updates, for incorporation by Owner into the O&M manuals.

3.3 INSTALLATION OF OCCUPANCY SENSORS

- A. Occupancy Sensors shall be mounted with the clear view of area to be controlled.
- B. To prevent false activation units shall be installed a minimum of 4 ft. away from air diffusers and other sources of strong air turbulence.
- C. Power packs shall be installed in clean outlet boxes. Wiring shall be terminated correctly and adequately tightened. Damaged or inoperative devices shall be replaced as necessary.
- D. Exact location of power packs shall be based on observing good installation practice. Power Packs shall be located in accessible ceiling spaces. Attention shall be paid to all aspects of installation to ensure that there is the minimum aesthetic impact of the hardware on the appearance of the affected rooms. All control unit hardware shall be completely contained within a suitable NEMA type enclosure, with no exposed wire other than low voltage Class 2 wiring.
- E. Where occupancy sensor ties into a programmable lighting control system, Contractor shall coordinate occupancy sensor and lighting control system compatibility and wiring requirements.
- F. Standalone occupancy sensors not powered by a lighting control system shall be powered from the lighting circuit which they control.
- G. Unless otherwise indicated, occupancy sensor power packs shall be wired ahead of local switching.
- H. Sensor Testing and Adjustment: At the time of installation the Contractor shall be responsible for testing and adjusting each sensor for proper detection of motion appropriate to room usage. The Contractor shall follow the testing and adjustment procedures as written in the installation instructions for each sensor model. NOTE: Due to room conditions it may be necessary for the Contractor to make adjustments, change the location or type of sensor to obtain proper operation and coverage of the system in each room and should therefore make labor allowance for such changes and adjustments.
- I. System Commissioning: After Contractor has installed and adjusted sensors, factory representative shall make a minimum of one visit to ensure sensors are properly installed and adjusted. Contractor shall then make any modifications required for proper system operation including modifications as instructed by Owner or Engineer.
- J. Installation Compliance: Installation of electrical materials and control devices shall be in accordance with all electrical codes and regulations affecting this work.

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 266000 – SPECIAL SYSTEMS

Article	Title	Page
PART 1 - GENERAL		1
1.1	REFERENCES	1
1.2	GENERAL SPECIAL SYSTEM REQUIREMENTS	1
1.3	SCOPE OF WORK.....	1
1.4	DESCRIPTION OF SYSTEMS	2
1.5	SUBSTITUTIONS	2
PART 2 - PRODUCTS		2
2.1	SPECIAL EQUIPMENT	2
2.2	ELEVATORS	2
PART 3 - EXECUTION		4
3.1	SPECIAL EQUIPMENT INSTALLATION.....	4
3.2	ELEVATOR INSTALLATION	5

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SECTION 266000 - SPECIAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL SPECIAL SYSTEM REQUIREMENTS

- A. This section is intended to cover special systems and equipment and their installation applicable to the Contractor's work.
 - B. Contractor shall include all labor, and material for the complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
 - C. Contract drawings and specifications are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
 - D. Equipment Storage and Protection: In general, special system's equipment shall be stored in sheltered clean, dry area. If equipment must be stored in cool, damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect special system equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosure shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense.
 - E. Coordination: Following equipment shall be submitted by other contractors through Architect to Engineer. Reference SPECIAL EQUIPMENT article in this section for additional details. Shop drawing submittal shall be for coordinating voltage, ampacity and wiring requirements.
 - 1. Elevators
 - 2. Security systems
 - 3. Audio/visual systems
 - F. Seismic Requirements:
 - 1. Battery inverters, engine/generators and control shall be installed to prevent lateral movement and uplifting of equipment under seismic conditions.
 - 2. Seismic Anchors shall meet Section 262400 - VIBRATION AND SEISMIC CONTROL article.
 - G. Guarantee: Guarantee shall be as required in Section 260100, GUARANTEE article except as revised by specific articles on equipment specified in this section.
 - H. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part number listed in this section articles are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.
- 1.3 SCOPE OF WORK**
- A. Contractor shall provide power for the following special systems equipment as indicated:
 - 1. Elevators
 - 2. Security systems
 - 3. Audio/visual systems

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of required special systems equipment and devices:
1. Special Equipment: Contractor shall provide power for special equipment furnished by Owner and other contractors in accordance with SPECIAL EQUIPMENT article.
 2. Elevators: Contractor shall provide appropriate 3 phase power to the elevators.
 3. Electronic Security Systems: Contractor shall provide power to equipment where so indicated on Division 13 and Division 26 and 27 Drawings.

1.5 SUBSTITUTIONS

- A. See Section 260100. Substitutions shall also meet any additional requirements specified in this section under PART 2.

PART 2 - PRODUCTS

2.1 SPECIAL EQUIPMENT

- A. General: Contractor shall provide electrical rough-in and power wiring work for equipment furnished by Owner and equipment furnished and installed by other Contractors. Suppliers' submittals or shop drawings for special equipment should be submitted to the Architect/Engineer for coordination of voltage and ampacity prior to equipment being shipped to the job site. Refer to other sections of specifications Divisions 01 to 23 for additional information on the scope of electrical work to be performed in support of equipment not furnished under Division 26.
- B. Material and Application: Contractor shall provide power wiring and terminations for proper operation of following equipment:
1. Equipment furnished by other Contractors:
 - a. Conveying Systems:
 - 1) Elevators: Refer to ELEVATORS article this section.
 - b. Motor Driven Equipment:
 - 1) Projection screens
 - 2) Drapes
 - c. Division 23 Contractor:
 - 1) Reference Division 23 specifications Section 230500, MECHANICAL COORDINATION FOR ELECTRICAL WORK article.
 - 2) Reference Equipment Data Schedule.
 2. Equipment Furnished by Owner:
 - a. Office equipment (copying machines, data processing, etc.)
 - b. Laboratory equipment (centrifuges, incubators, refrigerators, fume hoods, etc.)
- C. Manufacturer: Refer to all previous sections of specifications Divisions 01 to 23 for possible manufacturer.

2.2 ELEVATORS

- A. General:
1. Contractor shall provide electrical work necessary to rough-in and make electrical conduit and wiring connections for elevator equipment specified.
 2. Service to be provided under this contract shall consist of furnishing and installing power and lighting wiring to appropriate elevator controller.
 3. Power, lighting and control wiring beyond power supply input lugs of elevator controllers in elevator machine room shall be by the elevator subcontractor.

4. Elevator power wiring and equipment required as part of this contract shall be installed in accordance with NEC.
5. Elevator Power Disconnect: Elevator disconnect shall be a disconnect switch (non-automatic circuit breaker) or automatic circuit breaker with a 120 volt shunt trip and a fused control power transformer. Each power disconnect shall be of appropriate voltage, poles, size, and type.
6. Smoke Detected Condition: Appropriate elevator controller will signal elevator to go to the designated level or alternate floor upon detection of smoke by any elevator lobby, or machine room smoke detectors. The emergency recall switch in the elevator lobby of the designated level or the emergency in-car switch provided by the elevator subcontractor will operate in conjunction with the smoke detectors as follows:
 - a. Elevator Lobby Emergency Recall Switch on Designated Level: For emergency control by firefighters, each elevator or bank of elevators will have a 3 position (ON/OFF/BYPASS) key-operated switch on designated level provided by elevator subcontractor.
 - 1) ON Position: Returns all elevator(s) controlled by the switch to fire command or designated level non-stop and opens their doors.
 - 2) OFF Position: Allows elevator(s) to operate normally but dependent on elevator lobby, and machine room smoke detectors.
 - 3) BYPASS Position: Allows elevator(s) to operate normally but bypasses activated smoke detectors in elevator lobbies, or machine room.
 - b. Emergency In-Car Switch: For emergency control by firefighters, each elevator will have a three-position (OFF/HOLD/ON) key-operated switch-operating panel in the cab. This switch will only be operative when the Elevator Lobby Emergency Recall Switch, indicated in the previous paragraph, is in the ON position or an associated elevator lobby, elevator machine room or an elevator hoistway smoke detector has detected smoke.
 - 1) OFF Position: Allows elevator to operate normally or under control of the Elevator Lobby Emergency Recall Switch on the designated level.
 - 2) HOLD Position: Elevator will remain at the level it's on with the doors open.
 - 3) ON Position: Elevator controls will only be controlled by the person in the elevator cab.
7. Elevators on "Standby (Emergency) Power": After engine/generators start and come on-line and elevator ATS operates, elevator controllers in emergency power mode shall signal elevators to go to the designated level. Elevator controllers shall then provide "one elevator at a time" operation per elevator bank while automatic transfer switch is closed on emergency power position. The only devices that will initiate recall of elevators to the designated level are:
 - a. Associated elevator lobby, hoistway or machine room smoke detectors.
 - b. Emergency recall switch on designated level.
8. Contractor shall be present at elevator test run by elevator supplier while elevators are on engine/generator standby power to assure proper operating sequence as indicated.
9. Coordination:
 - a. Contractor shall coordinate exact location of rough-ins with elevator equipment subcontractor.
 - b. Control, signal and communication wiring from PA, intercom, fire alarm, systems and power failure condition signal wiring from ATS to appropriate elevator controller shall be by Contractor under direction of Elevator Equipment Subcontractor.
 - c. Required wiring from elevator controllers to elevator hoistway junction box, from hoistway junction box to elevator cab via traveling cable and from elevator cab junction box to all devices on the elevator shall be provided by Elevator Subcontractor.

10. Elevator Automatic Power Disconnection System:

- a. Contractor shall furnish and install fire alarm system heat sensing fire detectors alongside each sprinkler head in the elevator machine room elevator pit and top of elevator hoistway.
- b. Coordinate location and quantity of sprinkler heads with fire protection drawings furnished by Fire Protection Contractor.
- c. Reference Section 264000, ELEVATOR POWER MODULE SWITCH article for additional details of elevator disconnect.
- d. Contacts of a fire alarm control module shall be wired to the elevator power disconnects' shunt trip. Activation of any heat detector in elevator machine room, pit or hoistway shall activate the fire alarm system. The fire alarm system's program shall then cause the control module's contacts to close thereby de-energizing power to the elevator by operation of the shunt trip on the elevator power module switch.

11. Disconnects for Car Lighting, Receptacles, Ventilation, Heating, and Air Conditioning: Provide a lockable 240 volt, 30 amp, three-pole, fusible disconnect switch with 20 amp fuses in machine room for car lighting, receptacles, ventilation, heating, and air conditioning. Quantity of disconnects shall match quantity of elevators. Each disconnect switch shall be identified with number of elevator or elevators controlled by the switch.

B. Material:

1. For wiring reference Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).
2. For conduit reference Section 261300 - RACEWAYS AND BOXES.
3. For elevators on standby power reference Section 264000, AUTOMATIC TRANSFER SWITCHES article for ATS signal wiring.
4. For elevator recall and power disconnection reference Section 267100, FIRE ALARM SYSTEM article for fire alarm heat sensing fire detectors and control modules.
5. Reference Division 14, ELEVATORS for elevator specifications.

C. Manufacturer: Reference Division 14, ELEVATORS article for possible manufacturer.

PART 3 - EXECUTION

3.1 SPECIAL EQUIPMENT INSTALLATION

- A. Equipment requiring electrical service connections shall be installed by Contractor in accordance with local trade practices.
- B. Plug caps, junction boxes, and other components attached to or integral with equipment will be furnished with equipment but shall be installed and connected by Contractor.
- C. Rough-in work and wiring shall be in strict accordance with shop drawings, wiring diagrams and instructions for respective items of equipment. Contractor shall be responsible for obtaining from other subcontractors or Owner, all information necessary to assure compatibility of electrical work with final detail requirements of equipment.
- D. Power wiring and conduit shall be provided by Contractor for special equipment unless otherwise noted.
- E. Local disconnecting means shall be provided by Contractor for special equipment unless otherwise noted.
- F. Where equipment is noted Rough-in Only, Contractor shall terminate wiring at equipment outlet in such a manner as to leave a minimum length of 5 ft. of wiring for future connection of equipment. Outlet box covers for such equipment shall be provided by Contractor and painted to match adjacent surfaces.
- G. Contractor shall include receipt, uncrating, transportation within project site, and storage under lock and key of all cables and loose electrical parts furnished by other subcontractors as part of equipment covered under this section.

3.2 ELEVATOR INSTALLATION

- A. Provide appropriate 3 phase power wiring with ground to elevator power switch module in elevator machine room. Contractor shall provide an identified disconnect switch for each elevator in location required by NEC. Disconnect switch for each elevator shall be identified with same number as the elevator driving machine. Power wiring shall be run from each elevator disconnect switch to the appropriate elevator controller.
- B. Contractor shall provide separate 240 volt, 30 amp, three-pole fusible switch with 20 amp fuses in the machine room for car lighting and accessories on each elevator. Feed each fusible switch from a 30 amp, 3 phase Emergency feeder circuit. Branch circuits from fuses in fusible switches shall be run to junction box at middle point of elevator travel in elevator shaft or elevator controller in accordance with elevator subcontractor's requirements.
- C. Provide 120 volt for signal circuits.
- D. Provide lights, light switches and 125 VAC, 20 amp GFCI duplex receptacles in elevator pit and elevator machine room.
- E. Provide dedicated single receptacle in elevator pit for sump pump.
- F. Contractor shall run fire alarm signal wiring from contacts of fire alarm relays or addressable control modules in elevator machine room to appropriate elevator controller for elevator recall.
- G. Reference Section 267100, FIRE ALARM SYSTEM article and subparagraph Elevator Controls for additional information.
- H. Contractor shall run two (2) No. 12 in 1/2 inch conduit from elevator automatic transfer switch to appropriate main dispatching elevator controller(s) to signal loss of normal power and system has to be switched to emergency power mode.

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INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 266500 – STANDBY POWER GENERATION SYSTEM (BELOW 600 VOLTS)

Article	Title	Page
PART 1	GENERAL.....	1
1.1	REFERENCES	1
1.2	GENERAL SYSTEM REQUIREMENTS.....	1
1.3	SCOPE OF WORK.....	1
1.4	DESCRIPTION OF SYSTEMS	2
1.5	SUBSTITUTIONS	2
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
1.7	GROUNDING AND BONDING SYSTEMS	2
PART 2	PRODUCTS.....	2
2.1	STANDBY POWER ENGINE/GENERATOR(S).....	2
2.2	ENGINE/GENERATOR PROTECTIVE HOUSING.....	12
2.3	SKID TYPE FUEL TANK	12
2.4	STANDBY POWER REMOTE ALARM ANNUNCIATOR PANEL (RAA).....	13
PART 3	EXECUTION	14
3.1	STANDBY ENGINE/GENERATOR INSTALLATION	14
3.2	ENGINE/GENERATOR PROTECTIVE HOUSING INSTALLATION	15
3.3	SKID TYPE FUEL TANK INSTALLATION.....	15
3.4	STANDBY POWER REMOTE ALARM ANNUNCIATOR (RAA) INSTALLATION.....	15
3.5	STANDBY POWER SYSTEM SHOP DRAWINGS	16
3.6	STANDBY POWER SYSTEM STARTUP TEST	17
3.7	STANDBY POWER SYSTEM ACCEPTANCE TEST.....	18

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SECTION 266500 - STANDBY POWER GENERATION SYSTEM (BELOW 600 VOLTS)

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL SYSTEM REQUIREMENTS

- A. This section is intended to cover the standby power generation system and equipment and their installation applicable to the Contractor's work.
- B. Contractor shall include all labor, and material for the complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Contract drawings and specifications are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Equipment Storage and Protection:
 - 1. In general, special system's equipment shall be stored in sheltered clean, dry area. If equipment must be stored in cool, damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect power generating equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosure shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense.
 - 2. Until final observation equipment, bus bars, terminals and other internal components shall be protected by Contractor form paint, plaster, cleaners, abrasives, dust, and spray by providing appropriate covers.
- E. Seismic Requirements:
 - 1. Engine/generator(s), standby power control center (SPCC) and day tank(s) shall be installed to prevent lateral movement and uplifting due to seismic forces.
 - 2. Seismic Anchors shall meet Section 262400 - VIBRATION AND SEISMIC CONTROL.
- F. Warranty: Warranty shall be as required in Section 260100, GUARANTEE article except as revised by specific articles on equipment specified in this section.
 - 1. The manufacturer of equipment shall provide warranties to the Owner for the Standby Power Generation System equipment. All "purchased" equipment shall be warranted against defects in workmanship and materials for 24 months after the date of "Substantial Completion" of the equipment installation, as determined by the Architect. Batteries for the engines shall have a longer warranty as specified.
- G. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part number listed in this section articles are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and/or install provide power for the following special systems equipment as indicated:
 - 1. Engine/generator(s)
 - 2. Skid tanks
 - 3. Standby power remote alarm annunciator (RAA)

- 4. Outdoor sound attenuated enclosure

1.4 DESCRIPTION OF SYSTEMS

- A. Following is a general description of the standby power generation system and equipment. Reference individual articles for additional description of operations.
- B. Standby Power Generating System:
 - 1. Engine/Generator and Skid Mounted Tank: Emergency diesel-fueled engine/generator(s) with a skid mounted day tank will be installed outside to provide emergency lighting and power to selected circuits during interruption of utility power.
 - 2. Upon loss of normal utility power, automatic transfer switch(es) will provide a signal to the engine/generator(s) to start and switch its loads from the transfer switch normal position to the emergency position to provide generator power.
 - 3. RAA will be provided in main electrical room.
- C. Standby Power Mode:
 - 1. Upon loss of normal utility power for any reason to an automatic transfer switch, the transfer switch having the failed normal power source will immediately provide a starting signal to the engine/generator(s).
- D. Diesel Fuel Storage: The 660 gallon integral subbase fuel tank shall be shipped to the site in one piece for ease in installation.
- E. Remote Alarm Annunciator: A RAA will be provided in the main electrical room to provide status indication of each generator on the standby power generating system.

1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Substitutions shall also meet any additional requirements specified in this section under PART 2 Article 2.1 Paragraph A.9.a.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to following:
 - 1. Reference STANDBY POWER SYSTEM SHOP DRAWINGS article for details
 - 2. Outdoor sound attenuated enclosure
 - 3. Skid tank
 - 4. Standby power remote alarm annunciator (RAA)

1.7 GROUNDING AND BONDING SYSTEMS

- A. Grounding and bonding of electrical system and equipment shall be provided in accordance with NEC.
- B. Reference Section 264500 - GROUNDING AND BONDING for grounding of generators.

PART 2 - PRODUCTS

2.1 STANDBY POWER ENGINE/GENERATOR(S)

- A. General:
 - 1. The standby power engine/generator(s) is part of the standby power generation system. This article covers requirements of an Emergency Power Supply System (EPSS) classified as Type 10, Class X, Level 1 consisting of an engine-driven standby power emergency generator used to supply power for operation of communication equipment, emergency lighting and essential building electrical loads during failure of normal utility power.

2. Engine/Generator Supplier's Unit Responsibility: Standby power engine/generator(s) and associated equipment and devices specified including the outdoor protective housing and skid tank and their required interface wiring shall be considered part of standby power generation system and shall be supplied through the engine/generator supplier. The engine/generator supplier shall be responsible for coordination and testing of all associated equipment, devices and correction of failures.
3. Supplier: Engine/generator(s), cranking system, day tank(s), muffler(s), protective housing, and other accessories shall be from single supplier. This supplier shall have parts and service available 24 hours per day in Metropolitan St. Louis, Missouri area. Maintenance contracts shall also be available.
4. Load Pickup: Load pickup capability to be such that rated voltage and frequency are obtained within 10 seconds after closing of contact in external or internal cranking circuits.
5. Factory Tests and Certified Data:
 - a. Engine/generator set to be shipped shall be factory assembled and factory tested for 100 percent full load capability, mechanical integrity and correct functioning of controls. Prototype tests are not acceptable.
 - b. Certified copies of factory test report shall be submitted with shop drawings. Reference Section 260100, TESTING article for additional details.
6. System Description: Installation is based on a new 450 kW, kVA at 0.80 PF, 60 Hertz, wye connected 277/480 volt diesel-fueled standby rated engine/generator set.
7. Manufacturer: Units specified are produced by Caterpillar Inc. Equal units meeting the drawings and specification requirements by Cummins Power Generation or Kohler Co., will be considered.
8. Substitutions:
 - a. Detailed specifications describe general arrangement preferred but are not intended to eliminate consideration of alternative methods or equipment, which may be standard with certain manufacturers. Such variations from requirements of these specifications shall, however, be communicated to Engineer by clearly identifying variations on the first shop drawing submission.
 - b. Generating equipment of equal or greater performance by other manufacturers, within specified voltage, kVA, kW range, of similar fuel consumption and similar cooling air, exhaust and dimensions will be considered. Increases in scope of any nature of supporting Division 23 or 26 work shall be communicated to and approved by Architect/Engineer prior to approval for procurement of engine/generator and associated equipment.
 - c. Space Allocation: Both physical and working space allocation indicated for standby power system and equipment is based on first-named manufacturer. In event physically larger engine/generator units and associated equipment is furnished, Contractor shall be responsible for making detailed installation drawings to match allocated space prior to ordering.
9. Codes and Standards:
 - a. Engine/generator shall be standard model, except as specified, of latest design and type in production at manufacturer's place of business. Both engine and generator shall be completely manufactured, tested and assembled in the USA.
 - b. Applicable Documents:

1)	NEMA No. MG 1	Motors and Generators
2)	NFPA Pub. No. 70	National Electrical Code
3)	MIL-STD No. 705 B	Military Standard for Generator Tests
4)	UL2200	Generator Sets 600 Volts or Less
 - c. Seismic Requirements: Contractor shall provide seismic anchors required for seismic anchoring of protective housing engine/generator and skid tank.

10. Responsibility of Contractor:

- a. Contractor shall provide electrical work required to furnish and install complete correctly operating standby power generating system, including coordination of work with other trades.
- b. Contractor shall perform uncrating and installation of standby power system equipment.
- c. Contractor shall provide seismic anchor bolts in correct location of concrete housekeeping pads for anchoring of protective housing vibration isolators of engine/generator and anchoring of skid tank skid to concrete pad. Contractor shall provide 6 inch (152.4 mm) reinforced concrete housekeeping pad for engine/generator.
- d. Contractor shall provide supporting switchgear, feeders and auxiliary equipment in conjunction with standby power system. Contractor shall also provide field power, signal and control wiring of transfer switch, engine/generator, day tank, remote alarm annunciator, jacket water heater, battery heater, battery charger, and other required system controls.
- e. Contractor shall be responsible for obtaining a clear understanding with suppliers for inclusion of specified services required by manufacturers.
- f. Manufacturer's Field Service Engineers and Factory Technicians Testing Fees: Contractor shall include in his bid costs for providing services of manufacturer's field service engineers and factory technicians during both startup and acceptance tests. Costs shall include work required to complete tests until complete system and associated equipment is accepted. Reference STANDBY POWER SYSTEM (STARTUP TEST) and STANDBY POWER SYSTEM (ACCEPTANCE TEST) articles for additional details.

11. Responsibility of Equipment Supplier:

- a. Engine/Generator Supplier's Unit Responsibility: Standby power equipment specified shall be considered part of standby power generation system and shall be supplied through engine/generator supplier. Engine/generator supplier shall have unit responsibility for coordinating and testing of associated equipment and correction of equipment failures.
- b. Engine/generator supplier shall provide components that are new and that have been factory tested.
- c. Engine/generator supplier shall provide supervision and inspection of installation work with the assistance of engineers from the manufacturers of other equipment such as the automatic transfer switch(es). Manufacturer's field engineers shall furnish startup test, acceptance test and all work required for tests until the complete emergency power supply system is correctly operating and is accepted by the Owner and Architect/Engineer as meeting these specifications. Reference STANDBY POWER SYSTEM (STARTUP TEST) and STANDBY POWER SYSTEM (ACCEPTANCE TEST) articles for details.
- d. Equipment supplier shall advise Contractor of material required to complete system installation, connection, ancillary services and specified testing. Equipment supplier shall provide adjustable supplemental load banks when necessary for load testing of the standby power system at the job site.
- e. Supplier shall not require Owner to furnish special external equipment in order to test or energize the standby power system.
- f. Training: Equipment supplier shall provide factory representative for period of one day or 8 hours to train Owner's maintenance personnel regarding operation and maintenance of standby power system.
- g. Factory Production Tests:
 - 1) Single-step load pickup.
 - 2) Transient and steady state governing.
 - 3) Safety shutdown device testing.
 - 4) Voltage regulation.

- 5) Rated power.
 - 6) Maximum power.
12. Work Under Division 23:
- a. Contractor shall provide mechanical work required to complete standby power system as defined in mechanical specifications and as indicated.
 - b. Salient items include Contractor furnishing and installing fuel storage tank, dampers, fuel piping, exhaust piping, exhaust thimble, bird screen, and piping. Contractor shall install skid tank(s), muffler(s), and vibration isolators.
13. Work Under Division 03: Contractor shall provide concrete housekeeping pads suitable for receipt of outdoor protective housing, engine/generator(s), and dual wall skid tank.
14. Preliminary Drawings:
- a. Within 6 weeks after order is received, supplier shall furnish two (2) certified outline prints drawn to scale and dimensioned. Drawings shall show complete assembled engine/generating unit(s) with dual wall skid tank and protective housing indicating size and location of fuel, exhaust, water, electrical and cranking battery connections. Drawings shall show optimum locations and mounting requirements for seismic vibration isolators under engine/generator's subbase.
 - b. In addition, dimensional drawings with both plan and elevation of peripheral equipment, including cranking batteries, charger(s), muffler(s), skid tank, panelboard, and remote alarm annunciator panel, shall be furnished.
15. Record Drawings: Record drawings shall show details of installation with equipment indicated and drawn to scale and dimensioned. Drawings shall be prepared by Contractor in accordance with RECORD DRAWINGS article in Section 260100 and shall include mechanical, plumbing and electrical work associated with the engine/generator units. NEC working clearances or working space shall also be indicated. Record drawings shall be submitted to Architect/Engineer for approval prior to authorization of final payment to Contractor. Record drawings shall be certified as to their correctness by signature of Contractor and shall be stamped or otherwise identified as RECORD DRAWINGS.
16. Nameplates: Controls and indicating lights shall be identified with appropriate nameplates.
17. SCR Tracking: Engine/generator shall be immune to SCR loads causing notching of the power wave form by providing a permanent magnet exciter, series boost, a synchronous voltage regulator and other appropriate equipment.
- B. Engine:
- 1. Rating: Engine shall have a standby power rating. Standby power rated engine shall continuously provide required horsepower for variable load for duration of each electrical power failure. Engine shall be capable of delivering required net horsepower up to 3300 ft. (1000 M) above sea level and at ambient temperature of 110 deg. F. (43 deg. C.).
 - 2. Construction: Engine shall be stationary, liquid cooled diesel-fueled, turbocharged, after-cooled, 1800 rpm, four (4) stroke cycle, V 8-cylinder type. Crankshaft bearings shall number at least one between each cylinder for in-line engines or one between each pair of cylinders in V configurations. Engine flywheel and crankshaft shall be statically and dynamically balanced within manufacturer's standard tolerances.
 - 3. Fuel System:
 - a. General: Engine shall utilize No. 2 ultra-low sulfur diesel fuel oil at consumption rate not exceeding 37 gallons per hour at full rated kW. Any limiting characteristics of fuel required to be used in engine to produce satisfactory performance shall be clearly identified on first shop drawing submission.
 - b. Engine Solenoid Valve: Each engine shall be equipped with an automatically controlled solenoid fuel valve for prompt and reliable starting, running and emergency shutdown.

- c. Injection System: Fuel injection system shall be of injection type and shall ensure operation of engine continuously at full or partial load with reasonably clear exhaust under conditions specified. Injection pumps and valves shall not require adjustment in service.
 - d. Fuel Filter and Lines: Fuel filters required for proper filtration shall be incorporated in fuel system and shall be mounted on power unit ahead of injection pumps. Filters shall be replaceable type elements easily removed. Fuel lines between injection pumps and valves shall be heavy seamless tubing. Length of these fuel lines shall be same to eliminate irregularity of fuel injection.
4. Cooling System:
- a. General: Outdoor engine shall be equipped with circulating pump, thermostatic water flow controls, valves, fittings, and other equipment required for the cooling system.
 - b. Pump: Engine-driven centrifugal type water circulating pump for engine cooling shall be capable of circulating the required gpm (L/s) through engine cooling system without leaking.
 - c. Coolant Drains: Drain cocks shall be provided in accessible locations on engine, and radiator to permit complete draining of the cooling system.
 - d. Coolant: Engine cooling system shall be provided with ethylene glycol for freeze protection to -30 deg. F. (-34 deg. C.) as well as rust-inhibiting and boil-over protection. Engine/generator supplier shall provide initial coolant fill of engine, and radiator and cooling system piping and shall replace any coolant lost during testing.
5. Radiator and Fan: Engine/generator shall be equipped with engine-mounted, factory-installed, factory-tested radiator with engine driven fan. Radiator shall be sized to provide adequate engine cooling for engine ambient from minus 20 deg. F. to plus 100 deg. F. (minus 29 deg. C. to plus 37.78 deg. C.).
6. Fuel Cooler: Fuel oil cooler placed on the engine's radiator shall maintain the fuel oil at the optimum temperature recommended by the generator set manufacturer while operating the generator set for 24 hours at full load.
7. Lubrication:
- a. General: Engine shall be equipped with an engine-driven positive displacement oil pump with intake screen and relief valve and oil cooler. Pressure lubrication shall be provided for all main, connecting rods and camshaft bearings, timing gears and valve rocker mechanism.
 - b. Oil Gauge: Oil level gauge shall be provided to indicate oil level during static checks.
 - c. Oil Filter: Oil filters and crankcase ventilator shall be provided. Full-flow lubrication oil filter shall be provided, easily accessible, equipped with an automatic, pressure-controlled bypass so that clogging of filter will not interfere with continuous operation of engine.
 - d. Oil Drain: Suitable drain for lubricating system shall be provided with cap and valve located to permit easy access. Drain pipe shall be extended and rigidly supported. Drain shall be mounted minimum of 6 inch (152.4 mm) above vibration isolators.
 - e. Oil Provisions: Engine/generator supplier shall provide initial fill of engine lubricating system and shall replace any oil lost during testing.
 - f. Type Lube Oil: Oil shall be special Type CD for use at low ambient temperature of -20 deg. F. (-29 deg. C.).
8. Air Filters: Air intake shall be equipped with dry-type air cleaners and silencers of adequate capacity to protect working parts of engine from dust and grit.
9. Cranking System: Cranking cycle for engine(s) shall be initiated manually or automatically. Manual initiation of the starting cycle can be accomplished by placing the engine's four-position selector switch on the engine control panel in the RUN position, the engine starting contacts shall close to initiate the cranking cycle of the engine/generator.

Placing this same switch in the AUTO position shall place the engine/generator in the automatic standby position. Upon loss of normal power to any ATS wired to standby power system, operation of a clock exerciser or operation of "Test Switch" on an ATS, the engine starting contacts shall close to initiate the cranking cycle of the engine. In the OFF position, the engine shall not start even though the remote start contacts close. This position shall also provide for immediate shutdown in case of an emergency. Reset of any fault shall also be accomplished by putting the switch to the OFF/RESET position.

- a. Starter: Engine shall be equipped with an electrical starting system, which shall operate on energy from Series 12 volt starting batteries. 24 volt starting motors and batteries shall be capable of cranking engine repeatedly at sufficient speed for starting engine in ambient temperature as low as -20 deg. F. (-29 deg. C.). Starting motor shall be equipped with a drive mechanism designed to engage and release positively and automatically.
- b. Cranking Cycle Limiter: Cranking limiter circuit to stop starting circuit in 75 seconds after cycling 15 seconds ON, 15 seconds at REST, 15 seconds ON, 15 seconds at REST and 15 seconds ON. An OVERCRANK red pilot and cranking reset button shall be provided on engine with remote wiring for RAA indicator light.
- c. Starting Batteries: Engines with two (2) starting motors shall have two (2) separate sets of starting batteries.
 - 1) Rating of starting batteries shall be sufficient to permit continuous cranking of engine without recharging at firing speed for two (2) times at 45 seconds with a 2 minute rest between cranks at engine starting temperature and battery at temperature of -20 deg. F. (-29 deg. C.)
 - 2) Starting batteries shall be provided for each engine and each starting motor. Batteries shall be capable of minimum of 300 cranking/discharge cycles.
 - 3) Batteries shall be heavy-duty, diesel starting, lead acid type manufactured by Caterpillar C&D, Exide Inc., GNB Industrial Battery Co. or YUASA. Batteries shall be same type and capacity, and be by single manufacturer. Batteries shall have 36 month warranty.
 - 4) Battery disconnect switch shall be provided.
- d. Battery Cables: Battery cables shall be provided of adequate size to assure proper starting voltage. Termination of battery leads shall be clearly marked on engine/generator as positive (+) and negative (-). Markers shall be attached to unit in such a manner that they will not become detached during shipment.
- e. Battery Enclosure:
 - 1) Battery enclosure box shall be provided inside engine/generator protective housing. Box shall be made of 16 gauge galvanized steel painted with acid resistant paint and be totally insulated. Box shall have holes for battery cables, heater wiring and venting.
 - 2) Integral thermostatically controlled (60 deg. F. (16 deg. C.), ON and 80 deg. F. (27 deg. C.), OFF) battery heating pad system (80 watts at 120 volts) shall be used in conjunction with the enclosed battery box. Battery heating pad shall be disconnected when engine starts by oil pressure switch.
- f. Automatic Two-Rate Battery Charger: Separately mounted battery charger shall be convection cooled in stainless steel housing and be completely automatic solid-state designed for charging engine starting batteries. Battery charger shall have automatic float/equalize output, automatic AC line compensation and battery discharge protection. Charger shall have AC circuit breaker, and four (4) diagnostic alarm lights and battery temperature compensation. Charger shall incorporate following features:
 - 1) Input: Emergency 120 VAC, single phase, 60 cycle.
 - 2) Output: Fully automatic two-rate battery float/equalize charger. Charger output voltage shall match that of cranking system batteries and charge each battery to 95 percent of its ampere hour rating within 36 hours.

- 3) Automatic Float-Equalize: Charger circuitry shall read battery voltage in order to apply the correct voltage to the batteries. Chargers with timer circuits are not acceptable. Battery low and high-voltage settings shall be adjustable only from inside the charger enclosure. The charger "equalize mode" shall automatically become energized when the battery low-voltage setting is reached. When the high-voltage setting is reached the charger shall automatically switch from the equalize mode to the "float mode." Equalize mode low-voltage setting shall be as recommended by battery manufacturer. Battery temperature corrected specific gravity of all cells shall also be taken into account. Electrolyte level of all cells shall be higher than top of the separator in all cells before charging.
 - 4) Auxiliaries: Charger shall have following minimum auxiliary requirements. DC voltmeter (2 percent accuracy), DC ammeter (2 percent accuracy), fuse protection, on/off switch, AC Power On pilot light.
 - 5) Charger Remote Alarm Indicators: Auxiliary contacts and terminals shall be provided on alarm relays for connection of "BATT CHARGER MALFUNCTION" and "BATT LO VOLT" indicating lights on engine mounted control panel.
 - 6) Standards: Charger shall be UL listed and meet EGSA standards.
 - 7) Mounting: Charger shall be wall-mounted at side of generator control panel. Charger shall be provided with wall mounting flanges top and bottom.
 - 8) Warranty: Charger shall have minimum of 2 year limited warranty.
 - 9) Manufacturer: Charger manufacturer shall be Caterpillar, Charles Industries Inc., or SENS, with required options. Local charge failure alarm bell shall be furnished and installed.
- g. Battery Charging Alternator: Engine shall have a 45 amp belt-driven DC alternator with transistorized voltage regulator. Alternator output voltage shall match that of cranking system batteries.
10. Governor:
- a. Electronic Type:
 - 1) Engine speed shall be controlled by electronically controlled single unit, speed control governor power wired to engine starting batteries. Governor shall be solid-state controller used for controlling an engine-mounted fuel control actuator in response to frequency signals received from engine-mounted flywheel magnetic pickup. Governor shall be manufactured by Caterpillar, Barber-Coleman Co., AMBAC International or Woodward Governor Co.
 - 2) Isochronous (constant speed) governor shall operate to automatically reset speed droop from no load to full load to rated rpm.
 - b. Controller Mounting: Electronic governor controller shall be mounted on engine/generator.
 - c. Speed Setting Pot Mounting: Remote speed-setting potentiometer shall be mounted on engine/generator control panel.
11. Subbase: Entire engine/generator assembly shall be mounted on subbase. Subbase shall be of welded steel construction and adequately cross-braced. Engine/generator shall be securely fastened to subbase with bolts. Holes shall be provided in subbase for fastening to vibration isolators specified and skid tank. Exact locations of vibration isolators shall be determined by engine/generator supplier. See Vibration Paragraph G. for additional details.
12. Couplings: Couplings between engine and generator shall be of flexible steel disc type or approved equivalent. Couplings shall be torsionally matched to engine and generator.

C. Generator:

1. Synchronous: Generator(s) shall be maintenance free, single bearing, four-pole, 1800 rpm synchronous type, brushless alternator in a ventilated dripproof enclosure. Rotor shall be dynamically balanced and permanently aligned to engine with manufacturer's recommended flexible coupling. Generator shall have direct-drive centrifugal blower for proper cooling.
2. Insulation: Insulation to be NEMA Class F with temperature rise based on a nominal NEMA MG1 standby duty rating for 104 deg. F. (40 deg. C.) ambient, -12 deg. C. hot spot, and 221 deg. F. (105 deg. C.) temperature rise.
3. Starting kVA: Minimum 1000 skVA at 20 percent voltage dip.
4. Subtransient Reactance ($X''D$): Maximum 10.3 percent.
5. Windings: Generator rotor shall be supplied with pole face amortisseur or damper windings to damp out oscillations or hunting during load changes. Rotor windings shall be copper and have multiple dips and bakes of epoxy varnish. Generator stator windings shall be copper and receive multiple dips and bakes of epoxy varnish with fungus inhibitors. Insulation on stator shall be applied using vacuum pressure impregnated (VPI) system. Rotor shall receive multiple dips and bakes of insulation. Generators shall have 2/3 pitch windings that will not generate third harmonic currents. Provide 120 volt strip heaters for windings.
6. Enclosure and Junction Box: Enclosures of generator shall be dripproof with an output junction box. It shall be possible to locate the output junction box located on either side of generator.
7. AC Voltage Waveform Total Harmonic Distortion (THD): The sum of AC voltage waveform harmonics from no-load to full linear load shall not exceed 5 percent of rated voltage (L-N, L-L and L-L-L) and no single harmonic shall exceed 3 percent of rated voltage.
8. Telephone Influence Factor (TIF): Generator inductive effect on nearby telephone circuits shall be limited by normal TIF of less than 50.
9. Conduit Connections: Generator output feeder from junction box to generator circuit breaker shall be sized by Contractor for minimum of 115 percent full-load rating of engine/generator unit. Feeders shall be checked for correct phase rotation. Raceway connections for power and control wiring to generating units shall be flexible type for vibration isolation.
10. Generator Tests: Generators shall be tested in production according to MIL-STD 705 B. Following standard tests shall be performed:
 - a. Winding resistance
 - b. Insulation resistance of all windings
 - c. High potential test on all windings
 - d. Air gap measurement
 - e. Regulator operation
 - f. Exciter field current
 - g. Voltage balance

D. Voltage Regulator:

1. General: Voltage regulator shall automatically control voltage output of generator within specified range. Regulator shall be solid-state type incorporating use of transistors and/or SCRs. Voltage regulator shall compare generator 3 phase terminal voltage to referenced 3 phase voltage and use error signal to control excitation level of generator in case of load unbalance. Voltage regulator shall be manufactured by Basler Electric or approved equal.
2. Full Load Response: Maximum instantaneous rms voltage dip shall be less than 25 percent of rated voltage when full 3 phase rated load at rated power factor is applied to alternator. Recovery to steady operation shall occur within 5 second(s).
3. Voltage Regulator Range: Regulator shall be capable of regulating voltage output to within $\pm 1/2$ percent of rated voltage between no load and full load, in temperatures from 32 to 122 deg. F. (0 to 50 deg. C.) and between loads of 80 percent p.f. and 100 percent

- p.f. including at any given steady load condition. Regulator must be capable of adjustment from 10 percent below lowest rated voltage and 10 percent above highest rated voltage at no load by manual adjustable rheostat.
4. Voltage Regulator and Adjustment Rheostat Mounting: Voltage regulator and voltage adjusting rheostat shall be supplied by manufacturer of generator for mounting in generator control panel. Regulator shall be shock mounted for protection against vibration.
 5. Radio Interference Suppression: Voltage regulator shall be bonded and shielded to reduce electromagnetic interference (EMI)
 6. Current Boost:
 - a. High-performance voltage regulator shall be provided to allow generator to provide 250 to 300 percent rated current for 10 seconds for selective tripping of down-line protection devices upon short circuit.
 - b. This shall be accomplished using a PMG or internal excitation principle.
- E. AC Rotating Brushless Exciter: Exciter (rotor) armature shall be directly connected to generator shaft and shall be designed to operate with generator supplied. Exciter shall have solid-state, hermetically sealed rectifiers in an assembly mounted on armature. Armature rotor shall not be connected to generator field windings with intervening brushes, slip rings or commutators. Rectifiers and assembly shall withstand centrifugal force created by a 25 percent engine overspeed.
- F. Instruments and Safety Devices on Engine/Generator:
1. General: Each engine/generator shall be equipped with those instrumentation and control devices, which, because of operational necessity, must be mounted on engine or generator. Such components include but not limited to starting solenoid, overspeed trip and fuel rack solenoid. Contractor shall provide all conduit and wire from engine/generator to RAA alarms and indicators specified.
 2. Digital Control Panel: Unit-mounted engine/generator control panel shall be supplied. Controls, lamp indicators, and meters shall be clearly identified as to function by suitable nameplates. Control panel shall contain following:
 - a. Selector Membrane: Three-position selector switch RUN, OFF and AUTO with local red indicator (indicates safety position of switch) shall be provided. "RUN" position allows manual initiation of the engine starting circuit. "OFF" position shall make the engine starting system inoperative for maintenance work. "AUTO" position allows remote starting and stopping of the engine. Reference appropriate following subparagraph for alarm and indication when this switch is placed in other than the "AUTO" position.
 - b. Digital Display: Ammeter, voltmeter, frequency and battery charging meters shall be provided. Ammeter and voltmeter shall each have a phase selector switch. Meters shall be 2 percent accuracy type or better.
 - c. Overcrank Indicating Light: Local light shall automatically illuminate when specified cranking cycle has been exceeded and engine shuts down. Contacts and terminals shall be provided for wiring to "OVERCRANK" pilot and audible alarm on both local engine/generator control panel and RAA.
 3. Engine Instruments:
 - a. Lubricating oil pressure gauge
 - b. Cooling water temperature gauge
 4. Generator Main Circuit Breaker: Generator circuit breaker shall have shunt trip to be operated by overspeed device. Generator circuit breaker shall protect generator from overloads and provide inverse time delay for minimum of 10 seconds at 300 percent rated current tripping before tripping open. Time delay should allow Current Boost to provide selective tripping of down-line protection devices upon short circuit. Circuit breaker shall be three-pole, molded case type adjustable electronic trip and be supplied by the engine/generator manufacturer.

G. Vibration:

1. Operating parts of running engine/generator shall be reasonably free from noise and vibration to prevent injury to engine/generator and associated equipment.
2. Mounting of Controls: Control adjustments used for regulating voltage, speed, fuel, cooling water, lubricating oil pressure and such parts shall shock mounted.
3. Vibration Isolators: Seismic type vibration isolators and anchor bolts shall be furnished by manufacturer listed in Section 262400 - VIBRATION AND SEISMIC CONTROL.

H. Nameplates:

1. Nameplate(s) shall be attached to each engine/generator in conspicuous location showing unit, engine and generator manufacturer's name, model and serial number.
2. Engine bore, stroke, firing order, generator and exciter kW, kVA, voltage, current, phase, speed, frequency, and temperature rating shall also be included.
3. Engine/generator control panel shall be provided with large red nameplate with 1/2 inch (12.7 mm) high white lettering stating following:

DANGER!
THIS IS A FULLY AUTOMATIC EMERGENCY SYSTEM CONTROL,
ENGINE MAY START AT ANY TIME!
DO NOT REMOVE COVERS OR ATTEMPT MAINTENANCE
WITH ENGINE IN AUTOMATIC MODE.

I. Guards: Moving parts shall have metal guards to prevent entanglement of falling objects and provide personnel protection.

J. Finish: Complete engine/generator shall be given finishing coat of manufacturer's standard heat-resisting enamel. Extra quart of enamel used shall be shipped with unit for touch-up. Contractor shall touch-up unit to provide quality finish.

K. Fuel Provisions: Contractor shall provide initial fill of skid tank and shall replace any fuel oil used for engine/generator testing.

L. System Accessories: Each engine/generator shall be furnished and installed with following accessories. Size, manufacturer's name, and part number shall be listed for each accessory submitted with shop drawings.

1. Muffler: Furnish single end inlet Critical Grade exhaust muffler suitable for horizontal mounting outdoors inside the protective housing in 14 inch (355.6 mm) exhaust piping. Threaded condensate drain plug shall be provided at each end of muffler. Muffler shall be manufactured by GT Exhaust, Riley-Beaird or equal by Nelson Industries, Inc. or Burgess-Manning, Inc.
2. Flex Exhaust Pipe: For vibration isolation provide minimum 2 ft. (609.6 mm) length of seamless, corrugated flexible stainless steel exhaust hose with suitable stainless steel or carbon steel couplings on each end.
3. Flex Fuel Pipe: Seamless corrugated, flexible rubber hose with reinforced textile braid and single metal braided cover shall be provided with pipe thread couplings, suitable for use as diesel fuel connections to supply and return fittings on day tank and engine. Hose shall be good for ambients in range of -40 deg. F. to +300 deg. F. (-40 deg. C. to +149 deg. C.) Flex fuel pipe may be manufactured by Stratoflex Inc. or approved equal.
4. Heaters: Jacket water heaters with integral thermostats shall provide reliable starting of engines in -20 deg. F. (-29 deg. C.) ambient by maintaining engine jacket water at 90 deg. F. (32 deg. C.). Jacket water heaters shall be Watlow or KIM (Hotstart) 240 volt, 2500 watt units per generating set, all operating at 208 volts, single phase. Contractor shall wire heaters to normal system power source panelboard.
5. Panelboard: Provide circuit breaker panelboard mounted inside the protective housing alongside the battery charger at an accessible location on the generator control panel. Provide required breakers for engine/generator heaters, battery heating pad, and battery charger. Reference Section 264000, PANELBOARDS article for detailed requirements of panelboard.

- M. Spare Parts: (One set required.)
 - 1. Two (2) sets of fuel oil filters
 - 2. Two (2) sets of lube oil filters
 - 3. Two (2) sets water filters
 - 4. Two (2) air cleaner elements
 - 5. One set of all belts
 - 6. One set fuses for each size used in engine controller
 - 7. Five (5) sets of indicating lamps for each size used
 - 8. One hydrometer, for testing battery acid
 - 9. One set special wrenches in accordance with manufacturer's recommendation for routine maintenance.
 - 10. One detailed set of operation and maintenance manuals
- N. Engine/Generator Supplier Services: Engine/generator supplier shall include services of field engineers for following:
 - 1. Supervision of engine/generator installation.
 - 2. Proper operation of engine/generator and generator circuit breaker.
 - 3. Check out operating and control functions of engine/generator after installation.
 - 4. Startup test of engine/generator.
 - 5. Acceptance test of engine/generator.
 - 6. Correction of malfunctions such as elimination of oil and water leaks, mis-wiring and improper control functions found during testing.
 - 7. Instruct Owner's personnel at site in proper operation and routine maintenance of engine/generator and controls. This shall be done immediately after completion of acceptance test.

2.2 ENGINE/GENERATOR PROTECTIVE HOUSING

- A. General: The protective sound attenuated housing is part of the standby power system and have a sound level of 51 dB(A) at 19 ft. Engine/generator supplier shall provide outdoor reinforced weather-protective sound attenuated housing constructed of heavy gauge steel and have weatherproof finish. Housing shall cover engine/generator completely and be bolting to skid tank. Supplier shall provide one pint of touch-up paint of color selected by Architect/Engineer for application after installation of housing. Maximum housing length shall be 22 ft.
- B. Material and Application: Easy access to engine/generator batteries, battery heating pad, battery charger, jacket water heaters, and other accessories shall be provided by removable panels on each side. Access to engine/generator mounted instrument and control panel shall be provided with lockable, hinged doors. Unit shall be attached to engine/generator mounting base and radiator cowl.
- C. Manufacturer: Protective sound attenuated housing manufacturer shall be same as engine/generator.

2.3 SKID TYPE FUEL TANK

- A. General:
 - 1. The dual wall skid tank is part of the standby power system. Provide fuel tank and piping, solenoid valves, and a fuel gauge for indicating amount of fuel in the fuel tank and low level alarm float switch set at 17 gallons (64.35 liters).
 - 2. The sub-base fuel system is listed under UL 142, sub-section entitled Special Purpose Tanks EFVT category, and will bear their mark of UL approval according to their particular classification.
 - 3. The above ground steel secondary containment rectangular tank for use as a subbase for diesel generators is manufactured and intended to be installed in accordance with the Flammable and Combustible Liquids Code – NFPA-30, the Standard for Installation and

Use of Stationary Combustible Engine and Gas Turbines – NFPA-37, and Emergency and Standby Power Systems – NFPA-110.

B. Materials and Applications:

1. Subbase dual wall fuel tank shall be welded steel construction with holes for manual fuel inlet, fuel suction, fuel return, venting, and fuel gauge, and low-level float switch. For draining provide drain pet cock at bottom of both primary and secondary basin. Manual fuel inlet shall be 2 inch (50.8 mm) in diameter and have lockable removable lid. Interior of tank shall be sandblasted and have epoxy coating. Exterior of tank shall be sandblasted, rustproofed and painted with all-weather enamel.
2. Tank steel subbase shall have mounting holes on the top of both side rails for mounting seismic vibration isolators and holes on bottom of both side rails for fastening anchor bolts to concrete floor pad. Both skid side rails shall have appropriate lifting eyes at each end.
3. Provide minimum of 1/2 inch (12.7 mm) steel plates to bottom of tank and side rails to keep tank off the concrete housekeeping pad.
4. Fuel Provisions: Engine/generator supplier shall provide initial fill of subbase fuel tank.
5. Conduit Opening: Provide large opening completely through skid tank, approximately 8 inch x 10 inch (203.2 mm x 254 mm) near generator end. Openings shall permit room for generator output feeder, panelboard feeder and conduit with monitor and control wiring to the fire alarm system, RAA and ATS.
6. Alarms: Provide both high and low level alarm contacts.
7. Leak Detection System: Locate in secondary basin. Provide audible and visual alarm in the event of a fuel tank leak.
8. Fuel Gauges: A direct reading, UL listed, magnetic fuel level gauge with a hermetically sealed vacuum tested dial shall be provided to eliminate fogging.
9. Venting: Normal venting shall be sized in accordance with the American Petroleum Institute Standard No. 2000, Venting Atmospheric and Low-Pressure Storage Tanks, not less than 1-1/4 inch (31.75 mm) nominal inside diameter. Provide a 1-1/4 inch (31.75 mm) atmospheric mushroom vent cap. Contractor shall pipe above the highest fill point.

- C. Manufacturer: Skid tank shall be manufactured by Simplex Inc. of Springfield, Illinois, Pryco Inc. of Mechanicsburg, Illinois or the engine/generator manufacturer.

2.4 STANDBY POWER REMOTE ALARM ANNUNCIATOR PANEL (RAA)

A. General:

1. Provide a standby power RAA with alarms, indicators and controls in accordance with NFPA 110 requirements, and as listed below.
 - a. Generator Alarm (Fault Condition): Indicates engine shutdown and will give both audible and visual signals.
 - b. Generator Prealarm (Warning Condition): Indicates possibility of engine shutdown and will give both audible and visual signals.
 - c. Auxiliary Systems (Alarm): Indicates an auxiliary system component alarm and will give both audible and visual signals.
 - d. Generator (Status): Indicates generator running on-line status by visual signal only.
2. Standby power remote alarm annunciator cover plate shall be factory standard.

- B. Material and Applications: Following items are to be part of standby power remote alarm annunciator.

1. Generator Alarm (Fault Conditions): For generator provide as listed below.

	<u>Nameplate Engraving</u>	<u>Visual Alarm Pilot Light Color</u>
a.	Overspeed	red
b.	Overcrank	red

	<u>Nameplate Engraving</u>	<u>Visual Alarm Pilot Light Color</u>
c.	Lo Lube Oil Press	red
d.	Hi Engine Temp	red

2. Generator Prealarm (Warning Conditions): For generator provide as listed below.

	<u>Nameplate Engraving</u>	<u>Visual Alarm Pilot Light Color</u>
a.	Hi Engine Temp	amber
b.	Lo Lube Oil Press	amber
c.	Lo Water Temp	amber
d.	Batt Charger Malfunction	amber
e.	Generator Running	amber
f.	Low Fuel Level	amber

3. Auto Transfer Switch (Status): Provide (white) normal and (red) generator visual indication for two (2) automatic transfer switches. Provide two (2) nameplates to read "Auto Transfer Switch" top line and "LIFE SAFETY" "225 amp", and "STAND BY" "400 amp" or other designation on bottom line as Architect/Engineer may require to suit job requirements.
4. Wiring: Provide internal wiring for devices to terminal blocks and wiring diagrams for field wiring from RAA to each ATS transfer switch, each engine/generator control panel on generator main fuel tank and each battery charger.
5. Lamp Test P.B.: Provide single lamp test pushbutton to simultaneously test all fault, warning and status lamps on annunciator panel or provide individual push-to-test type pilot lights.
6. Common Audible Alarm: Battery powered audible alarm horn. Alarm shall have storage battery as a power source good for 20 hours of continuous operation.
7. Silence P.B.: Alarm silence pushbutton switch shall permit silencing an alarm prior to resetting "fault condition" or to acknowledge a "warning condition".
8. Alarm Indicating Light: Indicating light shall illuminate upon activation of any audible alarm and remain illuminated until the "fault condition" or "warning condition" is cleared or reset.
9. Nameplate: Provide black phenolic nameplate on front top of annunciator with following white engraved words:

"EMERGENCY GENERATOR"line one
 "IS LOCATED"line two
 "OUTSIDE"line three

10. Supplier: Supplier shall be same as engine/generator or ATS.

PART 3 - EXECUTION

3.1 STANDBY ENGINE/GENERATOR INSTALLATION

- A. Engine/generator installation shall meet 1998 NFPA-37.
- B. Concrete-reinforced housekeeping pad shall be of correct size and in correct location. Reference Section 260500, CONCRETE WORK article. Set seismic anchor bolts in concrete housekeeping pad for vibration isolators skid tank. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL.
- C. After housekeeping pad has cured, engine/generator shall be installed in strict accordance with manufacturer's installation instructions. Care shall be taken to lift skid tank and engine/generator set using correct lifting brackets. Contractor shall be careful to maintain a horizontal position throughout lift. Lifting cables or chain shall not come in contact with air cleaner, generator connection box, engine manifolds and other components on the set, or protective housing while lifting.

- D. Engine/generator shall be bolted to vibration isolators and to housekeeping pad skid tank subbase with anchor bolts in accordance with installation instructions. Contractor shall provide all mounting hardware not provided by engine/generator supplier. Piping or ductwork to engine shall be isolated with flexible fittings.
- E. Liquidtight flexible metal conduit section(s) shall be installed between engine/generator and:
 - 1. Generator feeders to distribution system and ATS.
 - 2. Control and monitor wiring to RAA and ATS.
 - 3. Accessory power supply wiring from panelboard for items such as jacket water heaters, battery charger, battery heater.
 - 4. Low-level fuel alarm wiring from main tank.
- F. All wiring to equipment on an engine shall be stranded type wire of adequate size to minimize breakage due to vibration. Bushings shall be installed in conduit fittings to protect wiring from abrasion with conduit terminations. Contractor shall provide all control and monitor wiring from engine(s) and generator(s) to remote ATS, and RAA necessary to provide proper operation of standby power system. Contractor shall also provide all power wiring to jacket water heaters, battery charger and battery heaters.
- G. Starting batteries in enclosure with heating pad shall be located as close as practicable to prime mover starting motor to minimize voltage drop. Battery cables shall be sized in accordance with manufacturer's recommendations and accepted engineering practices.
- H. Reference STANDBY POWER SYSTEM STARTUP TEST and ACCEPTANCE TEST articles this section for additional installation requirements.
- I. Interior of generator(s) shall be vacuum cleaned just prior to final observation.

3.2 ENGINE/GENERATOR PROTECTIVE HOUSING INSTALLATION

- A. Protective housing shall be factory installed on engine/generator skid. Unit shall be mounted to allow adequate air circulation.
- B. Engine muffler shall be rigidly mounted and have rain shield. Manufacturer shall mount muffler inside enclosure.
- C. Housing access panels shall be accessible and removable. Locks shall be provided on each access panel with keys provided to the Owner. Locks shall be keyed alike. Type locks and keys shall be approved by the Owner.

3.3 SKID TYPE FUEL TANK INSTALLATION

- A. Skid tank installation shall meet NFPA-37 and 110. Provide a minimum of 3 ft. (914.4 mm) clear on all sides.
- B. Concrete reinforced housekeeping pad shall be of correct size and in correct location. Reference Section 260500, CONCRETE WORK article. Set seismic anchor bolts in concrete housekeeping pad. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL.
- C. Openings in tank shall be protected by appropriate piping plugs to prevent infiltration of dirt and water during installation. Piping between day tank and engine shall be inspected and be free of dirt, fillings, water, and other contaminants prior to making connections.
- D. Remote Fuel Oil Pumps: Remote fuel oil pumps shall be provided on Level B2 for pumping fuel to day tanks mounted in penthouse. Wire fuel pumps to automatically start and stop by operation of float switches in day tank.
- E. Fuel Provisions: Contractor shall provide initial fill of day tank and shall replace any fuel used for engine/generator testing.

3.4 STANDBY POWER REMOTE ALARM ANNUNCIATOR (RAA) INSTALLATION

- A. Rigidly mount RAA.

- B. Install signal and/or control wiring required from each ATS, skid tank, and engine/generator to the RAA.
- C. Verify components are operating correctly.

3.5 STANDBY POWER SYSTEM SHOP DRAWINGS

- A. Material shall be bound into brochure to facilitate processing and filing. Index shall identify all material within brochure. Material shall have index tabs for separation of material into major divisions. Pages shall be consecutively numbered within each major division. Major divisions of shop drawings for this specific installation shall be engine, generator, protective housing, day tank, remote alarm annunciator and miscellaneous equipment. Shop drawings shall include manufacturer's name of components and include but not be limited to following:
- B. Engine/Generator:
 - 1. Delivery schedule from receipt of order.
 - 2. Engine/generator specification and design feature data.
 - 3. Engine/generator set wiring diagrams and descriptive data.
 - 4. Engine/generator installation drawings and instructions, including anchoring details, elevation and floor plans.
 - 5. Performance for generator kW output, efficiency and engine speed.
 - 6. Manufacturer shall submit certified test reports on factory production tests.
 - 7. Copy of routine maintenance, operation and testing manual.
 - 8. Engine/generator controls and instrumentation with all nameplate locations, sizes, lettering, and wording.
 - 9. Coordination of mounting of seismic vibration isolators.
- C. Engine:
 - 1. Engine torque, horsepower and fuel consumption curves.
 - 2. Radiator and fan descriptive and dimensional data.
 - 3. Airflow requirements for cooling and combustion, plus heat rejection of engine and generator when operating at full load based on manufacturer's data.
 - 4. Muffler back pressure due to muffler installation. Muffler dimensions, sound attenuation and drain plug details.
 - 5. Flexible exhaust and fuel piping, and flexible raceway details.
 - 6. Battery, battery charger, battery heating pad and battery enclosure data.
 - 7. Proof of battery's capability to provide two (2) 45 second continuous cranking cycles.
 - 8. Governor and voltage regulator data and wiring diagrams.
 - 9. Jacket water heater and wiring diagram.
 - 10. Type lubrication oil installed in crankcase.
 - 11. Spare parts list.
- D. Generator:
 - 1. Descriptive data of generator's stator and rotor coil winding material, insulation type, insulation process, generator type duty, and insulation temperature rise.
 - 2. Bearing details.
 - 3. Generator voltage connection diagram.
 - 4. Exciter wiring diagram including current boost and voltage regulator connections.
 - 5. Current boost, voltage regulator and winding strip heater details and their wiring diagrams.
 - 6. Generator circuit breaker specifications. Proof that generator circuit breaker will protect generator from damage by providing overlays of generator circuit breaker and generator damage curve.
- E. Skid Tank:
 - 1. Skid tank descriptive data on all components including insulation.
 - 2. Skid tank dimensional data.
 - 3. Location and size of all full lines, inlets, outlets, and vents.

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4. Wiring diagram of leak detection system and alarm contacts and float switches.
5. Installation drawings and instructions.

F. Protective Housing:

1. Protective housing descriptive data on all components. Include quantity, size and location of removable access panels.
2. Location of panelboard, lighting fixtures and switches on engine/generator.
3. Protective housing dimensional data.
4. Installation drawings and instructions.

G. RAA:

1. Standby power remote alarm annunciator drawing with height, width and depth indicated.
2. Generator alarm, generator prealarm, auxiliary system status, ATS status, generator status with audible and visual indicators. ATS keyed test switches shall be indicated and correctly labeled.
3. Nameplate locations, size, lettering type, and wording.

H. Miscellaneous:

1. Supplier's card and evidence of local 24 hour per day service and parts availability, and letter evidencing single source of service for both engine and generator assembly.
2. Details on specified warranty.

3.6 STANDBY POWER SYSTEM STARTUP TEST

- A. Field Engineers:** Contractor shall provide services of field engineers of engine/generator, circuit breaker, and ATS manufacturers for supervision of startup tests.
- B. Preliminary Requirements:** Each engine/generator shall be completely assembled and engine thoroughly run-in, with voltage, frequency and speed adjustments made, oil and water leaks eliminated, wires, conduits, controls and accessories permanently installed, and other necessary adjustments completed before startup test is initiated.
- C. Startup Test:** Upon completion of preliminary requirements and calibration and adjustment of controls, Contractor shall perform startup test with all designated loads connected to generator and supplementary load banks. Contractor shall perform tests under the supervision and partnership with the engine/generator, and ATS equipment manufacturer's field engineers.
- D. Engine/Generator Startup Test:** Field test shall include operating engine generating unit for approximately 4 hour carrying full load. Contractor shall furnish all lubricants. Engine manufacturer shall furnish and connect test instruments necessary to determine engine fuel consumption and output of each generator. Building mechanical and lighting loads and/or adjustable supplemental load banks for full load operation shall be used for this test. Engine generating unit shall be tested in accordance with Field Test Code listed in Standard Practices for Stationary Diesel & Gas Engines published by Diesel Engine Manufacturer's Association.
- E. Certified Startup Test Report:** Test records shall be part of startup test. Contractor shall furnish and record completion of each item on separate log prepared for each engine/generator, generator main circuit breaker, each ATS and SPCC control function. Certified test report shall be forwarded to Engineer for review in accordance with Section 260100, TESTING article. Certified test report shall include all items in same sequence as following:
1. Fuel System: Check all piping joints, engine fuel pump operation, gauge operation, pump, and alarms, signals, and controls, and proper operation of remote fuel oil pumps.
 2. Battery System: Check and record voltage and electrolyte specific gravity of each battery cell, cable connections, starter operation, and verify AC supply to battery charger and DC output is terminated correctly.
 3. Fuel Log: Record fuel levels of day tank and storage tank prior to tests and verify proper fuel consumption for load. Check for leaks in fuel system piping joints and valves.
 4. Generator: Record voltage, frequency and kW loading with all assigned loads connected to system. Also with generator approximately 75 percent loaded, record voltage dip and

recovery time when single greatest motor starting load of system is added as specified in Article 2.1 C. Generator subparagraph Motor Starting Requirements.

5. Engine Starting System: Check for engine start from each remote ATS equipped with engine starting contacts and manual start system. Check engine starting batteries by checking following:
 - a. Check electrolyte level in each cell to make sure it is above plates.
 - b. Clean corrosion from battery terminals.
 - c. Vent caps should be in place and secure. Make sure vent holes are not plugged.
 - d. Check battery hold down clamps to make sure they are fastened securely.
 - e. If battery failure occurs problem may be due to malfunction in charging system, such as defective alternator or voltage regulator.
6. Startup Time: Record total seconds elapsed, from initiation of each generator start signal from each ATS to time it takes generator to reach 90 percent of rated voltage and frequency.
7. Automatic Transfer Switches (ATS): Record time delay relay settings, pilot light operation and voltage at normal, emergency and load terminals of each transfer switch. Check phase rotation on all systems with all possible configurations of ATS.
8. Cooling System: Record fill of coolant before and after test. check for leaks in cooling system piping joints and valves.
9. Lubricants: Record fill of lubricants before and after test.
10. Gauge Readings (at full load): Record water temperature, lube oil pressure, fuel oil level gauge at half hour intervals during 4 hour test run.
11. Alarm Signals and Operations: Simulate operation of each item of generator's fault conditions listed on RAA. Reference STANDBY POWER REMOTE ALARM ANNUNCIATOR article for details. Record operation of all alarms and indicating lights and stopping of engine and tripping of generator circuit breaker as appropriate.
12. Mounting: Check vibration isolator clearances and proper installation before tests and note any adjustments.
13. Exhaust System: Inspect for integrity of joints, freedom from obstructions, excessive vibration, and noise transmission to adjacent areas and to point of discharge.
14. Engine Cool Down Time: Record the total time from the simulated restoration of utility or normal service till the time the engine shuts down. Initial setting on the ATS normally is 5 minutes.
15. Controls on Engine/Generator: Check proper operation of all automatic and manual control devices, all alarms and status indicators and signals for the ATSS. Each generator circuit breaker shall be tested at construction site before it is put in service. Circuit breakers shall be adjusted as required so that they will trip only after allowing 300 percent of rated generator current for minimum of 10 seconds. Testing for generator circuit breakers by hand held test kit shall be as follows:
 - a. Functional testing of long time delay setting.
 - b. Functional testing instantaneous pickup setting.
 - c. Functional testing of ground fault pickup setting and time delay setting.
16. Generator circuit breakers shall be set in accordance with the SHORT CIRCUIT AND PROTECTIVE DEVICE AND ARC FLASH STUDIES REPORT article in Section 260100.

3.7 STANDBY POWER SYSTEM ACCEPTANCE TEST

A. General:

1. Final acceptance test shall be conducted by Contractor at job site after startup test has been completed. Contractor shall notify equipment manufacturer field engineers, Owner and Architect/Engineer 2 weeks in advance of test. Equipment manufacturer's field engineers, Owner and Architect/Engineer shall all be present for Acceptance Test.
2. If, during test, equipment does not meet test requirements for reason of incorrect installations, Contractor will be responsible for correcting errors and rerunning tests until acceptance test meets approval of Owner and Architect/Engineer. Faulty operation of

equipment during test shall be corrected by manufacturer of faulty equipment. Should any repairs be extensive (longer than 2 hours), tests shall be rerun as soon as possible by Contractor at a time and date agreeable to all parties present. Owner and Architect/Engineer shall not provide additional compensation for rerunning tests.

B. Engine/Generator Acceptance Tests:

1. Visual inspection for fluid leaks or other irregularities.
2. Two (2) Hour Test: Run each diesel-electric set at no-load, only until temperature of jacket water stabilizes, at half load for 1/2 hour, at 3/4 load for 1/2 hour and full load for 1 hour. Measure jacket water and lube oil temperature and pressure. Exhaust temperatures shall also be measured at each load level. Contractor shall provide supplemental load bank, and provide instruments and fuel.
3. Fuel consumption shall be measured at each load step in accordance with NEMA Standard practice.
4. Cranking system, automatic controls, safety shutdowns and other systems shall be demonstrated to be in good working condition.
5. When tests are complete, a second visual examination shall be made. Lube oil shall be checked and changed.
6. Contractor shall furnish all fuel and lubricants. Engine/generator manufacturer shall furnish supplementary load bank and all instruments necessary to conduct test and shall connect instruments required to determine engine fuel consumption and output of generator.
7. Building mechanical and lighting loads and a supplementary load bank shall be used for this generator acceptance test.

C. Automatic Transfer Switch Acceptance Test:

1. Simulate utility power failure at each ATS by opening of circuit breaker or fusible switch feeding Normal side of transfer switch. Upon sensing loss of voltage, generators shall start and appropriate ATS shall operate properly.
2. Simulate utility power failure at each ATS by switching ATS two-position test switch to "Generator Start Test" position and releasing. Engine/generator shall start and two-position switch shall return to "Automatic" position.

D. Acceptance: When preceding tests are correctly performed in presence of Architect/Engineer and Owner, it will constitute acceptance of standby power system and equipment.

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INDEX

DIVISION 26 - ELECTRICAL WORK

SECTION 267100 - FIRE ALARM SYSTEMS

Article	Title	Page
PART 1	- GENERAL.....	1
1.1	REFERENCES	1
1.2	GENERAL FIRE ALARM REQUIREMENTS	1
1.3	SCOPE OF WORK.....	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	2
PART 2	- PRODUCTS.....	2
2.1	FIRE ALARM SYSTEM	2
PART 3	- EXECUTION	11
3.1	FIRE ALARM SYSTEM INSTALLATION.....	11

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SECTION 267100 - FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL FIRE ALARM REQUIREMENTS

- A. This section is intended to cover fire alarm system equipment and its installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems. Fire alarm system installations shall be made by workmen skilled in electronics trade.
- C. Contract drawings and specification are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Adjustments: Make adjustments required for fire alarm systems under direction of each manufacturer or supplier's field supervisor.
- E. Codes and Standards:
 - 1. Fire alarm systems shall be provided in accordance with appropriate latest revised NFPA, IBC and NEC requirements.
 - 2. Telefire alarm system wiring pathways shall generally be separated from electrical power lines and equipment rated 480 volts or less in accordance with TIA/EIA-569-A "Commercial Building Standard for Telecommunications Pathways and Spaces."
- F. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install a new fire alarm system.

1.4 DESCRIPTION OF SYSTEMS

- A. Fire alarm system will consist of new fire alarm control panel and remote annunciator panels near fire department building entrance or control station. New fire alarm control panel will monitor existing fire alarm system for trouble, supervisory and general alarm. Manual pull stations, thermal detectors and smoke detectors will initiate general alarm. Sprinkler system waterflow switches will be monitored and initiate general alarm on waterflow. Sprinkler system tamper switches will be monitored and initiate supervisory alarm on valve closure. Fire alarm audible and visual devices located to provide general fire alarm evacuation signals. Fire alarm system will transmit alarm and trouble signals to an approved central station system, proprietary system or remote station system via digital alarm communicator transmitter and Owner's telephone lines.

1.5 SUBSTITUTIONS

- A. See Section 260100. Substitutions shall also meet the following requirements for proper evaluation of the substitution equipment or system to meet job requirements.

- B. Substitutions to fire alarm systems specified shall include following information:
1. Distributor's and the manufacturer's name of equipment and letter from manufacturer stating Fire Alarm Contractor is an authorized distributor capable of installing and servicing specified equipment.
 2. List and date of installations of similar equipment having been installed and satisfactorily operating in area by same manufacturer.
 3. Description of all deviations from specified system.
 4. Complete equipment list by model number, as well as list by paragraph number, of any model or functional deviation from base specified equipment. Dimensions, finishes and details on all controls shall also be provided.
 5. Engineering data and systems one-line wiring diagrams including cable, conduit and power requirements as well as other information Architect/Engineer may request for evaluation.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Contract drawings and specifications are provided for establishing scope of the system and are not intended to show all details nor quantity and sizes of wire and conduit. Contractor shall submit supplier's shop drawings to Architect/Engineer and receive his approval prior to commencing work or ordering materials. Fire alarm supplier shall be required to provide custom-prepared shop drawings to include CAD prepared one-line diagrams, floor plans, wiring schematics with a separate equipment brochure as indicated below.
- B. First Submittal (Prior to Ordering): Provide bound copy of manufacturer's equipment with all system components used on the job. The first page of each component shall be identified by specification page and paragraph as to where each is located in the specifications. Pages of brochure shall be consecutively numbered and have an overall index. Index shall have list of FA components with page numbers to locate components in the brochure.
- C. Second Submittal (After Ordering):
1. Wiring diagrams, floor plans and one-line/riser diagrams shall be drawn on CAD. Format of electronic files for CAD shall be the same as that required for RECORD DRAWINGS in Section 260100. One-line/riser diagram shall show all devices with fire alarm address identifications and indicate quantity and sizes of equipment, devices, conduit and wire. One-line/riser diagram shall also indicate individually which fire alarm smoke detector initiates system signals for control of which piece of air handling equipment by addressable control module. Operation of the fire alarm addressable control modules or Division 23 controller shall shutdown the air handling equipment.
 2. Floor plan(s) shall be drawn to scale and show location of each piece of fire alarm equipment or component. Plan(s) shall also show address identifications and location of any risers through floor.
 3. Point-to-point wiring diagram showing typical wiring of each type alarm initiating device, alarm indicating device, and auxiliary device both monitor and control.
 4. Corrected manufacturer's equipment brochure shall be included.
 5. Battery and voltage drop calculations for each initiating circuit.
 6. Fire alarm system sequence of controls matrix of all devices and functions.

PART 2 - PRODUCTS

2.1 FIRE ALARM SYSTEM

- A. General:
1. General Requirements:
 - a. Contractor shall provide labor, materials and equipment for automatic, supervised, addressable fire detection and alarm system as specified and indicated.

- b. Contractor shall provide all raceway and wire. Fire alarm system raceways shown are schematic. Raceways shall be EMT conduit when run exposed in unfinished areas and concealed above non-accessible ceilings.
 - c. Contract drawings and specifications are provided for establishing scope of the system and are not intended to show all details nor quantity and sizes of wire and raceways.
 - d. Installed Expansion Capacity: System installed shall provide a minimum of 25 percent additional capacity above that required for power supplies, address points and panel interior space.
 - e. System Expandability: New fire alarm system shall have provisions for expansion by the addition of fire alarm panels by the same manufacturer to accommodate expansion.
 - f. Fire Protection System Coordination: Contractor shall coordinate fire alarm system requirements with Division 23 Contractor as to location and quantity of tamper switches, flow switches and pressure switches and provide wire, conduit and fire alarm system components for a complete operating system.
2. Codes and Standards: Equipment shall be installed in accordance with appropriate requirements of NFPA, NEC, and IBC, and other applicable local codes. In case of variances, specification with the stricter requirements shall govern. System components shall be the standard product and be UL listed. Similar devices shall be by a single manufacturer. Contractor shall provide acceptance tests, preliminary and final Certificates of Compliance and documentation required to meet NFPA 72. Tests shall be performed by factory-trained technician.
3. Equipment Supplier Qualifications:
- a. The fire alarm equipment supplier shall have a NICET Level 3 certified individual on staff responsible for overseeing the technical design and engineering functions related to the fire alarm system. The NICET Level 3 certificate number must be submitted to the Engineer with shop drawing submittals.
 - b. The fire alarm equipment supplier shall have on staff NICET Level 2 technicians supervising the final connections and programming of the system.
4. General Description of System Operation: Fire alarm system unless otherwise noted shall operate in the alarm modes as follows:
- a. General Alarm Signal: Activation of any manual initiation device shall cause the fire alarm system "immediately" without delay to go into general alarm mode. Activation of automatic initiation device (e.g., smoke detector, heat detector, waterflow) shall cause the fire alarm system to go into general alarm mode. In the general alarm mode the following shall occur simultaneously:
 - 1) General alarm on fire alarm indicating devices shall activate throughout facility until the alarm is manually acknowledged and silenced at the control panel or a remote annunciator.
 - 2) Control panel and remote annunciators shall identify address of device, device type and location of device activated.
 - 3) General alarm signal shall also be transmitted to an approved central station system, proprietary system or a remote central station (contracted independent agency) via digital alarm communicator transmitter (DACT) and Owner's dedicated telephone lines.
 - 4) Functions above shall remain activated until the automatic device in alarm is cleared and the system is reset.
 - 5) Release smoke doors.
 - 6) Detection of smoke by smoke detectors in the associated elevator lobby, or elevator machine room or elevator hoistway shall initiate recall of associated elevator(s) by the appropriate elevator controller.
 - 7) Alarm will be stored in solid-state event history log in the fire alarm control panel.

- 8) Upon a subsequent alarm initiation signal the system shall automatically reactivate the general alarm.
 - b. Supervisory Signal: Activation of supervisory initiation device (e.g. tamper switch, level switch, fire pump alarms) shall cause the fire alarm system to go into the supervisory alarm mode. In this mode the following shall occur simultaneously:
 - 1) Supervisory alarm on fire alarm system shall activate supervisory signal until alarm is manually acknowledged and silenced at the control panel or a remote annunciator.
 - 2) Control panel and remote annunciators shall identify address of device, device type and location of device activated.
 - 3) Supervisory alarm signal shall also be transmitted to an approved central-station system, proprietary system or a remote central station (contracted independent agency) via digital alarm communicator transmitter (DACT) and Owner's dedicated telephone lines.
 - 4) Functions above shall remain activated until the supervisory alarm is cleared and the system is reset.
 - 5) Alarm will be stored in solid-state event history log in the fire alarm control panel.
 - 6) Upon a subsequent alarm initiation signal the system shall automatically reactivate the supervisory alarm.
 - c. Trouble Signals: Derangement of wiring or devices by power failures, opens or grounds shall cause fire alarm system to go into the trouble alarm mode. In this mode following shall occur simultaneously:
 - 1) Trouble alarm on fire alarm system shall activate trouble signal until alarm is manually acknowledged and silenced at the control panel or annunciators.
 - 2) Control panel and annunciators shall identify address of device, device type and location of device activated.
 - 3) Trouble alarm signal shall also be transmitted to an approved central-station system, proprietary system or a remote central station (contracted independent agency) via digital alarm communicator transmitter (DACT) and Owner's dedicated telephone lines.
 - 4) Functions above shall remain activated until the trouble alarm is cleared and the system is reset.
 - 5) Alarm will be stored in solid-state history log in the fire alarm control panel.
 - 6) Upon a subsequent alarm initiation signal the system shall automatically reactivate the trouble alarm.
5. Tie for Both New and Existing Fire Alarm Systems: Provide all interface control and monitoring devices as well as wiring necessary to tie the two systems together.
 - a. Existing fire alarm system in the East Academic Building shall be wired to new fire alarm system to permit new system to activate new alarm indicating devices when the existing system goes into alarm.
 - b. New fire alarm system shall be wired to existing fire alarm system in the East Academic Building to permit existing system to activate existing alarm indicating devices when the new system goes into alarm.
6. System Installation Supervision, Service and Training: Fire alarm system installation shall be provided by the Contractor under supervision of manufacturer/supplier's representative. Equipment manufacturer/supplier shall furnish a factory-trained representative for final checkout of system. Fire alarm system and accessories shall be from a single supplier. Supplier shall have parts and service available 24 hours per day within Metropolitan St. Louis, Missouri area. Maintenance contracts shall also be available. Manufacturer/supplier shall furnish half day (4 hours) of training for Owner in the operation of the system.

7. Elevator Controls: Refer to Section 266000, ELEVATORS article for operation of elevator controls during smoke detected condition.
 8. Wiring and Raceways:
 - a. Wiring shall be installed in conduit (EMT) unless otherwise specified. Vertical risers, wiring drops in wall and wiring in mechanical spaces shall be in conduit (EMT) unless otherwise specified. Any fire alarm system raceways shown are schematic only.
 - b. Initiating device circuits (IDC) shall be two-wire Style C (Class B).
 - c. Notification Appliance Circuits (NAC) shall be two-wire Style Y (Class B) with remote EOL device.
 - d. Signaling Line Circuits (SLC) shall be two-wire Style 4 (Class B).
 - e. Data trunk lines between networked FACP's and FDP's shall be Style 6 (Class A).
 9. Environmental limitations for system equipment shall be as follows:
 - a. Temperature: 32 deg. F. to 120 deg. F.
 - b. Humidity: 10 to 90 percent non-condensing
 10. Any variations between what is specified and what particular manufacturer wishes to furnish in lieu of that specified shall be submitted to Architect/Engineer for approval. Reference article entitled SUBSTITUTIONS for additional details.
 11. Primary Power and Trouble Power:
 - a. Primary power for fire alarm system and peripheral equipment shall be derived from dedicated 120 VAC, single phase emergency branch circuits. AC power shall be monitored and a power on LED shall be provided. Upon failure of primary power source, system shall indicate a trouble condition and light a circuit trouble LED indicating primary power failure. Transfer to secondary (standby) power shall be automatic and within 30 seconds.
 - b. Panelboard: Branch circuit breaker providing AC power shall be identified with a phenolic nameplate reading FIRE ALARM CIRCUIT CONTROL.
 - c. Nameplate on fire alarm panel shall identify the panelboard providing the fire alarm system primary power.
 12. Secondary (Standby) Power:
 - a. Storage batteries shall be rechargeable lead calcium or nickel cadmium cells. Batteries shall be mounted in the fire alarm cabinet with proper protection barriers. Maximum normal load of batteries shall not exceed 2 amperes per cell.
 - b. Storage batteries shall be capable of operating the system within 10 seconds under maximum normal load conditions for 24 hours and then be capable of operating all general alarm notification appliances (audible and visual) for 5 consecutive minutes.
 - c. Charger shall be an integral part of the panel and shall be dual rate with automatic charging. Undervoltage detection must be provided and when detected shall initiate trouble alarm. Batteries shall, after full discharge cycle, be restored after 48 hours to meet requirements of preceding paragraphs.
 13. Power line voltage surge, transient and noise protection shall be provided and be applicable to equipment specified.
 14. Guarantee: Entire installation shall carry a 1 year guarantee for all parts and labor after acceptance of system by Owner. Acceptance is defined as date upon which all approval agencies, Architect/Engineer, insurance underwriter inspector, and local authorities have granted approval of system installation. Allied trades shall guarantee installation, material and labor provided under this section of work.
- B. Material and Application: New Equipment shall consist of, but not be limited to remote network annunciators, remote power supplies, manual pull stations, automatic detectors, and alarm indicating devices. Wiring shall be placed in raceways unless otherwise indicated. Wiring not in raceways shall be plenum rated and properly supported.

1. Central Fire Alarm Equipment: Equipment shall consist of fire command station with wall-mounted central processing unit (CPU), and panel-mounted CRT, keypad and printer. Audio, control and power modules shall be mounted in separate surface-mounted cabinets.
2. Alarm Initiating Devices:
 - a. Manual Pull Stations: Manual pull stations shall be addressable normally open, dual-action type keyed lock to allow resetting. Station shall be ADA Type by operating on minimum of 5 pounds pull.
 - 1) Units shall have red finish with white lettering.
 - 2) Station shall be operated by pulling down on lever which will actuate a switch to initiate a general alarm.
 - 3) Stations shall be keyed alike to allow access to station for resetting of switch.
 - 4) Manual stations shall be semi-flush mounted in finished areas and surface mounted in unfinished areas.
 - 5) Address identification shall be affixed to the inside of the station.
 - 6) Each wire must be electrically supervised.
 - b. Smoke Detectors:
 - 1) General Requirements: Smoke sensing fire detectors shall be addressable analogue type mounted on separate base and allow 360 degrees smoke entry. Each detector shall be monitored to measure any change in their sensitivity due to the environment (dirt, smoke, temperature, or humidity).
 - a) Smoke detectors shall have provisions to deter unauthorized tampering or removal from base. Smoke detectors shall operate satisfactory in air velocity range of 0 to 1500 ft./min. Detectors located at return air ducts above the suspended ceiling shall have remote LED annunciation feature.
 - b) Smoke detector shall contain integral visual alarm visible for minimum of 180 degrees. Where a remote external indication is required, the integral indicator shall remain active. Detectors located in return air plenum above suspended ceilings shall have remote annunciation feature.
 - c) Smoke detectors shall not be installed in areas where ambient is likely to exceed 100 deg. F. or fall below 32 deg. F. or relative humidity is above 93 percent or air velocity is greater than 300 ft./min., unless they are specifically UL listed for such temperatures.
 - 2) Smoke Door Smoke Detectors: Smoke doors provided with automatic hold-open devices or door operators shall be released or de-energized by fire alarm system upon detection of smoke by a local smoke detector located on ceiling on either side of door openings. Local auxiliary relay addressable control module contacts shall open to release doors.
 - 3) Elevator Lobbies, Hoistway and Associated Machine Room Smoke Detectors: Smoke detectors in each elevator lobby, elevator hoistway and elevator machine room shall signal the fire alarm system to operate one of two (2) remote addressable control modules at elevator controller for elevator recall to the appropriate floor.
 - a) Elevators serving the same elevator lobby or being served from the same machine room where a smoke detector is in alarm shall be captured and recalled to (designated level) fire command floor or an alternate level as appropriate.
 - b) See Paragraph C.17 for elevator power disconnection on water flow in elevator hoistway and machine room.

- c. Duct Smoke Detectors:
 - 1) General Requirements: Smoke sensing duct detectors shall be addressable type. Contractor shall furnish and wire duct detectors return air of each air handling unit and at all smoke dampers. Installation of duct detectors will be by Division 23 Contractor. Contractor shall provide supervised power wiring from fire alarm panel for all smoke detectors.
 - a) Detector housing shall be UL listed for this application and each component circuit shall be fully supervised.
 - b) Detector housing shall be designed for mounting on duct or air handling unit housing. Detector shall be complete with inlet and exhaust sampling tubes of appropriate lengths for insertion perpendicular to air stream. Detector shall operate satisfactory in air velocity range of 500 to 4000 ft./min. Sampling tubes shall extend across complete width of duct.
 - 2) Remote LED with Nameplate: Provide a remote alarm light or LED in a visible and accessible location with appropriate nameplate indicating AHU or RTU identification by unique number and supply or return duct system.
 - 3) Detector shall have adjustable sensitivity with a minimum setting not less than UL standards and shall not be subject to alarm from rapid humidity changes. Detectors shall operate in minimum 32 to 120 deg. F. air with 20 to 85 percent relative humidity.
- d. Heat Detectors:
 - 1) Heat sensing addressable fire detectors for mounting on ceilings, pendants or boxes shall be addressable fixed-temperature, 135 deg. F. type. Detector shall be mounted on a separate base.
 - 2) Heat sensing fire detectors in elevator machine room and elevator hoistway shall be located at each sprinkler head to signal to the fire alarm system. The fire alarm system shall then signal the addressable control module to operate the shunt trip on elevator power module switch to provide disconnecting of power to elevators prior to help prevent excessive water damage by an activated sprinkler.
- 3. Alarm-Indicating Devices Audible and Visual: Alarm-indicating devices shall have corrosionproof, red finish. Signaling devices shall not be wired in series. In large areas 80 ft. x 80 ft. and larger where two (2) or more audible or visual devices are spaced less than 55 ft. apart, they shall be synchronized. Fire alarm strobes are shown with candela intensity to meet NFPA and ADAAG minimum requirements. Contractor not having the specific intensity shown shall provide a strobe with a larger intensity level to meet NFPA and ADAAG requirements.
 - a. Wall-Mounted ADA Horn/Strobes: Horn/strobes shall be semi-recessed mounted electrically-operated, supervised, 24 VDC with electronic horn tone type with "UL Rated" minimum output of 85 dB at 10 ft. Strobe shall be UL listed with minimum candela output of 15/75, 30/75, 60/75 or 95 at ADA flashing rate of 1 Hertz. Unit shall be identified with the word "FIRE". Provide the necessary power supplies in a fire alarm panel or remote. Synchronization of strobes shall be provided when necessary to meet NFPA 72.
 - b. Wall-Mounted Alarm Strobes: Flashing visual alarms shall be UL listed with minimum candela output of 15/75, 30/75, 60/75, or 95 at ADA flashing rate of 1 Hertz. Unit shall be identified with the word "FIRE". Provide the necessary power supplies in a fire alarm panel or remote. Synchronization of strobes shall be provided when necessary to meet NFPA 72.

4. Remote 24 VDC Power Supplies:
 - a. Remote 24 VDC power supplies for horns and strobes shall be enclosed in a compact ventilated lockable cabinet, approximately 15 inch x 15 inch x 4 inch deep. Power supply shall have its own lead-acid battery backup with charging circuit and supervision. Should any abnormality occur, it shall report it to the fire alarm system as a "trouble alarm" on its indicating alarm circuit (IAC). Power supply shall have LEDs for trouble monitoring. LEDs shall indicate AC on, AC failure/earth fault, battery/charger trouble, output 1, 2, 3, and 4. Power supply shall be wired to a dedicated 120 volt, 3 amp emergency circuit. Batteries shall be good for 4 hours with 5 minutes of operation.
 - b. Provide power supplies with power for the quantity of horns and visual alarm indicating devices shown plus minimum of 10 percent additional capacity.
 - c. Provide addressable control module to initiate horn and strobe operation.
 5. Digital Alarm Communicator Transmitter: The digital alarm communicator transmitter shall be UL listed and include the following features.
 - a. Meet NFPA 72 requirements for Digital Alarm Communicator Transmitter.
 - b. Capable of seizing the telephone line at the protected premises, disconnecting an outgoing or incoming call, and preventing its use until signal transmission has been completed.
 - c. Connected to two (2) separate telephone lines at protected premises.
 - d. Capable of selecting the operable line in the event of a failure on either line.
 - e. Programmed to call a second number should the signal transmission be unsuccessful.
 - f. Equipped with 4 hour battery pack, charger, telephone hijack, and dedicated 120 VAC receptacle.
 - g. Contractor will provide cable, connectors and installation of two (2) CO telephone lines and interface in accordance with FCC Part 68 using a USOC No. RJ31-X jack. Owner will furnish two (2) standard business telephone lines for this purpose.
 - h. Digital Communicator shall be connected to the fire alarm system to receive and transmit alarm signals, trouble conditions and supervisory conditions.
 6. Remote Wall-Mounted LCD Annunciator Panels:
 - a. Furnish and install semi-recessed mounted panels with standard finish. Panels shall have terminals for necessary field wiring. The annunciator shall include an eighty (80) character, back-lit LCD.
 - b. Annunciator shall display all system intelligent points. Upon activation of fire alarm initiating device LCD shall identify location of the device, type of device, and address of device in alarm or trouble.
 - c. Panel shall have acknowledge, silence and reset switches.
 - d. Fire alarm control panel shall provide power for remote annunciator panel. Circuiting between fire alarm control panel and annunciator panel shall be supervised.
- C. Additional Requirements:
1. Smoke Test Device: One UL listed smoke test device shall be provided to the Owner.
 2. Remote Addressable Control Modules: Contractor shall provide addressable control module with two (2) sets of Form C (NO and NC) dry contacts. Wire directly from dry contacts of the control module to perform the required control function unless the rating of the contacts will not meet the requirements. Where contacts are not adequate to meet the control requirements, provide an additional interposing relay with a coil of appropriate voltage and adequately rated contacts to perform the control function.
 - a. Fan Control: Units shall be provided (one for each air handling unit) at AHU or RTU starters to shutdown fan on detection of smoke by the associated duct detector. Locate alongside the appropriate temperature control panel or fan motor controller. Control module shall operate upon detection of smoke or water flow in

- fire alarm zone served by that air handling unit. Division 23 Contractor shall wire appropriate contacts for controlling appropriate fans and dampers in accordance with Section 239500.
- b. Elevators: Three (3) units shall be provided in each elevator machine room at appropriate elevator controller for elevator recall to appropriate floor. If hoistway or machine room is sprinkled two (2) additional unit shall be provided for elevator shutdown and shunt trip power monitor.
 - c. Smoke Doors: Units shall be provided at each set of smoke doors for de-energizing door holders or door closers upon detection of smoke by the door smoke detectors or upon general alarm.
 - d. Remote 24 VDC Power Supplies: Provide control module in remote mounted power supply enclosures to energize the audible and visual wired to the remote power supplies upon activation of the general alarm.
3. Remote Addressable Monitor Modules: Contractor shall provide addressable monitor modules. Wire the monitor modules to the normally open (N.O.) contacts of the system, equipment or device for monitoring a change-in-status of the contacts. Closure of the N.O. contacts will initiate an alarm signal to the fire alarm control panel through the addressable monitor module. The fire alarm control panel will in turn take the appropriate programmed action due to the change-in-status.
- a. Water Flow Switch: Units shall be provided at each sprinkler system water flow switch.
 - b. Sprinkler Tamper Switch: Units shall be provided at each sprinkler system tamper switch.
 - c. Fire Pump Tamper Switch: Units shall be provided at each fire pump tamper switch. Units shall also be provided for monitoring each fire pump supervisory signal.
 - d. Fire Suppression System: Units shall be provide at sprinkler system, backflow preventer tamper switches, and stand pipe tamper switches.
 - e. Elevator Disconnect: Provide monitor module to monitor 120 VAC circuit to the elevator circuit breaker trip.
4. Sprinkler Flow Switches and Valve Tamper Switches: Sprinkler flow switches and valve tamper switches shall be furnished by Division 23 Contractor. Both switches Form C (NO/NC) dry contacts shall be wired separately to a fire alarm system addressable monitor module.
- a. Flow switch and associated shutoff valve tamper switch shall be wired for separate fire alarm annunciation. Flow switch shall visually indicate "WATER FLOW" on the fire alarm annunciator and initiate fire alarm system general alarm.
 - b. Associated shutoff valve tamper switch when closed shall visually indicate "VALVE CLOSED" on fire alarm annunciator and initiate the fire alarm supervisory alarm.
 - c. Where interconnected sprinkler risers each with their own water flow switches are installed, multiple water flow alarms are a possibility when any sprinkler head operates. Where this condition exists all of these water flow switches shall be wired for single flow alarm indication. Each associated tamper switch shall be wired for separate supervisory indication.
 - d. Provide addressable monitor modules to signal the fire alarm system of the proper alarm function.
5. Fire Pump Valve Tamper Switches: Fire pump valve tamper switches shall be furnished by Division 23 Contractor. Switches shall have two (2) sets of NO/NC contacts to be wired to fire alarm system through addressable monitor module.
- a. Each tamper switch when closed shall visually indicate "VALVE CLOSED" on fire alarm annunciator and initiate fire alarm supervisory alarm.
 - b. Provide addressable monitor modules to signal the fire alarm system of the proper alarm function.

6. Fire Line Backflow Preventer Tamper Switches: Fire line backflow preventer tamper switches shall be furnished on backflow preventer isolation valves by Division 23 Contractor. Switch Form C (NO/NC) contacts shall be wired to the fire alarm system through an addressable monitor module.
 - a. Tamper switch when closed shall visually indicate "BACKFLOW PREVENTER VALVE CLOSED" on the fire alarm system and initiate fire alarm supervisory alarm.
 - b. Provide addressable monitor modules to signal the fire alarm system of the proper alarm function.
 7. Standpipe Tamper Switches: Standpipe tamper switches shall be furnished by Division 23 Contractor. Switch Form C (NO/NC) contacts shall be wired to the fire alarm system through an addressable monitor module.
 - a. Tamper switch when closed shall visually indicate "STANDPIPE VALVE CLOSED" on the fire alarm system and initiate the fire alarm supervisory alarm.
 - b. Provide addressable monitor modules to signal the fire alarm system of the proper alarm function.
 - c. Each system shall annunciate separately on the fire alarm system.
 8. Electric Fire Pump Supervisory Signals: Electric fire pump Form C (NO/NC) contacts shall be provided in pump controller to permit fire pump controller to indicate "FIRE PUMP WAS RUNNING", "FIRE PUMP POWER FAILURE" "FIRE PUMP PHASE REVERSAL" and "ALTERNATE POWER SOURCE" on the fire alarm system. Fire alarm system shall supervise these contacts through addressable monitor modules.
 9. Elevator Automatic Power Disconnection System:
 - a. General:
 - 1) Contractor shall furnish and install UL listed fixed temperature heat detectors alongside each sprinkler head in the elevator machine room and the elevator hoistway.
 - 2) Activation of any heat detector or flow switch in machine room or in hoistway shall signal the fire alarm system to energize the 120 volt shunt trip on circuit breaker providing power to the elevator(s). Provide addressable control module to energize shunt trip on elevator power module switch on signal from fire alarm system. Where necessary the Contractor shall provide interposing relays with contacts rated at larger ampacity than those of the addressable control module. Provide addressable monitor module to monitor the 120 volt power to the trip.
 - 3) Coordinate location of sprinklers heads and flow switch with fire protection drawings.
 10. System Reprogramming: Provide necessary programming and any reprogramming required to make components operate correctly as indicated or specified.
- D. Manufacturer/Supplier:
1. System specified is based on standard products of Notifier Fire Systems.
 2. Wiring outside of conduit shall be Teflon (FEP) 392 deg. F. or Kynar 257 deg. F. insulation with required 300 or 600 volt rating as manufactured by Belden, Berk-Tek, AUTOCHEM North America, Inc., or Pennwalt Corp.
 3. Equipment Supplier with Single-Source Responsibility: Obtain fire alarm components from a single source that will be responsibility for compatibility of system components. Equipment supplier shall be the manufacturer's local factory authorized representative and be factory authorized, trained and certified to perform warranty service for the equipment being supplied.

PART 3 - EXECUTION

3.1 FIRE ALARM SYSTEM INSTALLATION

A. General:

1. Supplier: Equipment supplier shall furnish Contractor with complete installation drawings for connection and installation of system components. Supplier shall provide services of factory-trained technician to assist Contractor during the term of the installation as required.
2. Training: Fire alarm system supplier shall also provide services of factory engineer to conduct one-day (8 hour) training program for maintenance department personnel. This program is to include detailed service and repair training on fire alarm system.
3. Cleaning and Test: After installation of equipment interior of all panels, cabinets or equipment shall be cleaned and all foreign matter removed. Upon completion of installation, entire system shall be tested. All items not operating correctly shall be repaired and be retested.
4. At final presentation of system to Owner, Contractor shall present two (2) sets of complete operating and maintenance instructions for installed system which shall include complete system wiring diagrams (standard diagram will not be acceptable) and clean, legible record drawings. One copy shall be good quality reproducible media.
5. Devices shall be recessed or semi-recessed in wall with conduit and box in wall unless otherwise indicated.

B. Installation of Fire Command Center: Fire command center shall be located near the building entrance or other location approved by the Authority Having Jurisdiction with minimum 3 ft. clearance from the front of the fire alarm control equipment.

C. Installation and Location of Manual Pull Stations:

1. Reference Section 260100, MOUNTING AND LOCATIONS article for mounting heights.
2. Manual stations shall be within 5 ft. of each floor or building exit. Additional manual pull stations shall be located so that the travel distance to nearest fire alarm box will not be in excess of 200 ft. measured horizontally on the same floor.
3. Manual stations must be accessible, unobstructed, visible and of same general type and appearance.

D. Installation and Location of Ceiling Smoke Detectors:

1. Detectors shall not be installed until final cleanup of area has taken place. Smoke detectors installed on ceilings shall not be mounted in a direct supply air stream nor closer than 3 ft. from air diffuser or air handling lighting fixture.
2. Detectors shall be readily accessible for cleaning and shall be mounted in accordance with manufacturer's recommendations. Where detector is above a non-accessible ceiling, Contractor shall provide access panel in the ceiling to permit accessibility.
3. Smoke detectors shall be coordinated with locations of other items in ceiling.
4. All points on flat ceilings in areas requiring smoke detectors shall have a detector located within 21 ft.. All areas requiring smoke detectors with sloped ceilings exceeding 10 degrees shall have detectors located on the ceiling within 3 ft. of the highest point. Areas with solid joist and beam construction requiring smoke detectors are to be installed in accordance with 2002 NFPA 72 Article 5.6.5.
5. Smoke detector shall be located at each fire alarm control panel and remote power supply.
6. Smoke detectors for automatic door closures on smoke doors shall be located within 5 ft. of door opening. Doors with transom heights exceeding 24 inch shall have a smoke detector on both sides of doorway.
7. Smoke detectors in elevator lobbies shall be located within 21 ft. of the centerline of each elevator door within the elevator bank under control of the detector.

- E. Installation of Smoke Detectors in Elevator Hoistways:
 - 1. Smoke detectors shall not be installed in elevator hoistways unless the top of the hoistway is protected by automatic sprinklers or where a smoke detector is required to activate the elevator hoistway smoke relief equipment.
 - 2. Where smoke detectors are required; they shall provide elevator recall before the heat detector or the waterflow switch on the hoistway sprinkler system actuates.
- F. Installation of Smoke Detectors at Return Air Opening:
 - 1. Detectors to be listed for the air velocity present at mounting location.
 - 2. Detectors shall be installed within 12 inch in front of or behind the opening.
 - 3. Multiple detectors required on openings exceeding 36 inch in width or 36 inch in depth. Quantity and locations of detectors to meet 2002 NFPA 72 Appendix A.5.14.4.2.2(a).
 - 4. Detectors shall be coordinated with piping and other items. Detectors shall not interfere with operation, maintenance or removal of grill.
 - 5. Detectors shall be accessible for cleaning. Access doors or panels shall be provided in accordance with NFPA 90A.
 - 6. Where smoke detectors are installed in concealed locations more than 10 ft. above the finished floor or in arrangements where the detector's alarm indicator is not visible to responding personnel, the detectors shall be provided with remote alarm indicators. Remote alarm indicators shall be installed in an accessible location and shall be clearly labeled to indicate both their function and the air handling unit(s) associated with each detector (for example, "RETURN GRILL SMOKE DETECTOR ALARM AHU-1").
- G. Installation of Duct Type Smoke Detectors with Sampling Tubes:
 - 1. Duct detectors shall be rigidly mounted outside the ductwork and installed in such a way as to obtain a representative sample of the air stream. Detectors should be located a minimum of six (6) duct-equivalent diameters from bends or other obstructions and inlets. Inlet tube shall span the entire duct width and installed so the inlet tube holes face upstream of airflow. Return tube slant cut face shall be oriented downstream of airflow. Tube support required for ducts more than 3 ft. wide.
 - 2. Detectors shall be accessible for cleaning. Access doors or panels shall be provided in accordance with NFPA 90A.
 - 3. Cut holes in ductwork as required for installation of duct detector with sampling tube in accordance with manufactures recommendations. All penetrations of air duct in the vicinity of detectors installed on or in an air duct shall be sealed to prevent entrance of outside air and possible dilution or reduction of smoke within the duct.
 - 4. Where in-duct smoke detectors are installed in concealed locations more than 10 ft. above the finished floor or in arrangements where the detector's alarm indicator is not visible to responding personnel, the detectors shall be provided with remote alarm indicators. Remote alarm indicators shall be installed in an accessible location and shall be clearly labeled to indicate both their function and the air-handling unit(s) associated with each detector (for example, "RETURN IN-DUCT SMOKE DETECTOR ALARM AHU-1").
- H. Installation and Location of Thermal Detectors:
 - 1. Detectors shall be mounted on their listed spacing or be corrected to different spacing to meet irregular shaped areas in accordance with 2002 NFPA 72, Article 5.6.5.1.2.
 - 2. Detector spacing on ceilings from 10 to 30 ft. above the floor shall be reduced in accordance with 2002 NFPA 72, Article 5.6.5.5.
 - 3. Spacing of detectors in areas with joist or beam construction shall be installed in accordance with 2002 NFPA 72, Article 5.6.3.
 - 4. Verify detectors are color coded in accordance with 2002 NFPA 72, Table 5.6.2.11.
 - 5. Thermal Detectors for Elevator Shutdown:
 - a. Rigidly mount heat detectors within 2 ft. of each sprinkler head in each elevator machine room and elevator shaft.

- b. Detector must have lower temperature rating and higher sensitivity as compared to sprinkler.
- I. Addressable Control and Monitor Modules:
 - 1. Locate and wire addressable control module within 3 ft. of AHU or RTU motor controller for fan shutdown.
 - 2. Locate and wire three (3) addressable monitor modules at existing fire alarm control panel in the East Academic Building to monitor general alarm, supervisory alarm, and trouble conditions.
 - 3. Locate and wire addressable control module at each smoke door or set of smoke doors with hold open devices.
 - 4. Locate and wire addressable monitor module at each water flow switch and tamper switch.
 - 5. Locate three (3) addressable control modules in elevator machine room at appropriate elevator controller for elevator recall and shutdown. The normally open contacts of machine rooms addressable control module's shall be wired to elevator power disconnects shunt trip. Activation of any elevator machine room or hoistway sprinkler head or heat detector shall cause addressable control module's contacts to close on signal from the fire alarm system to energize the shunt trip on the elevator power disconnect providing power to the elevator.
- J. Installation of Audible Alarms:
 - 1. Reference Section 260100, MOUNTING AND LOCATIONS article for mounting heights.
 - 2. Audible alarm notification appliances shall be located to provide a sound pressure level of 15 dBA above the average ambient sound level in every occupied space within the building.
- K. Installation of Visual Alarms:
 - 1. Reference Section 260100, MOUNTING AND LOCATIONS article for mounting heights.
 - 2. ADA alarm strobes shall be placed on wall at appropriate location in all "common use" passages, hallways, lobbies, corridors, toilets, conference rooms, meeting rooms, classrooms, cafeterias, filing, and photocopy rooms.
 - 3. Corridor Locations: Visual signal devices shall be placed on maximum 100 ft. centers in long continuous corridors. Visual signals shall also not be farther than 15 ft. from the end of the corridor.
 - 4. Synchronization: Where more than two (2) visual alarms are in the same room or within the field of view they shall be synchronized.
- L. Wiring and Raceway:
 - 1. General:
 - a. Wiring shall be insulated copper conductors installed in code-sized raceways. Only fire alarm wiring shall be installed in these raceways in accordance with NEC Article 760.
 - b. Wiring insulation shall be tested, with devices disconnected, to provide a minimum of one megohm resistance to ground.
 - c. Each wire must be electrically supervised.
 - d. Cables or individual wires in cabinets shall be carefully formed, laced and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded with the same label designation as that indicated on associated field or shop drawings. Controls, function switches, etc., shall be labeled on all equipment panels.
 - e. Wire and cable shall be continuous and free of splices for entire length of run between designated connections or terminations unless they are made in listed boxes, enclosures, devices or equipment in accordance with NEC Article 760. Transposing or changing color-coding of wires shall not be permitted. Bending radius of cables shall not be less than manufacturer's requirements.

- f. Class A initiating-device, signaling-line or notification-appliance outgoing and return (redundant) circuit conductors shall not be run in the same cable assembly, enclosure or raceway, unless "Ceramifiable" Insulation (CI) is used on said conductors.
 - 2. Wiring Not In A Raceway:
 - a. Wiring in vertical drops, risers, above inaccessible ceilings, or in areas without ceilings shall be in EMT conduit. No wiring other than that directly associated with fire alarm system shall be permitted in fire alarm raceways.
 - b. Where wiring is run above accessible ceilings not in conduit, it shall be supported a minimum of every 6 ft. of horizontal run. Wiring shall be run clear of ceiling, steam and hot water pipes, and ductwork.
 - c. Teflon or Kynar jacketed wiring above false ceilings or mounted above lower chord will be open cable wiring, using telephone type cable clips at intervals not to exceed every 8 ft.
 - d. Wiring shall be supported from support wires not supporting ceiling. Wiring shall not be supported from conduit and shall not prevent removal of ceiling panels.
 - 3. Wiring for initiating circuits shall be a minimum of #16 AWG; wiring for indicating circuits shall be minimum #16 AWG.
 - 4. Coaxial cables shall be properly routed and secured to preclude stress and deformation and shall meet requirements of Article 760 of NEC.
 - 5. Wiring shall be of type required in Article 760 of NEC.
- M. Identification:
- 1. Fire alarm initiating devices shall be identified by Contractor with fire alarm numerical address of the device. Identification tape shall be 1/2 inch wide and be securely placed on the inside of each pull station and each smoke detector. Identification tape shall be placed on the outside of each duct smoke detector housing at an accessible location.
 - 2. Sprinkler flow switches and tamper switches shall be identified with fire alarm numerical address of the device on a brass valve tag. Tags on flow switches shall be fastened to U-bolts and tags on OS&Y valves shall be fastened to yoke clear of valve operating parts with heavy-duty chain or S-rings. Tags, chain and S-rings shall be manufactured by Seton Nameplate Corp. or W.H. Brady Co.
 - 3. Junction, pull and terminal boxes used in conjunction with fire alarm systems shall be labeled "FIRE ALARM".
 - 4. Terminal and wire labels or markers shall be in accordance with fire alarm system manufacturer's wiring diagrams, NEC Article 760 and Section 261950 - ELECTRICAL IDENTIFICATION.

END OF SECTION 267100

INDEX

DIVISION 26 – ELECTRICAL WORK

SECTION 268500 – ELECTRIC HEATING

Article	Title	Page
PART 1 - GENERAL		1
1.1	RELATED DOCUMENTS	1
1.2	GENERAL ELECTRIC HEAT REQUIREMENTS	1
1.3	SCOPE OF WORK	1
1.4	DESCRIPTION OF SYSTEMS	1
1.5	SUBSTITUTIONS	1
1.6	SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS	1
PART 2 - PRODUCTS		1
2.1	PIPE FREEZE PROTECTION EQUIPMENT	1
PART 3 - EXECUTION		2
3.1	PIPE FREEZE PROTECTION EQUIPMENT INSTALLATION AND TEST	2

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SECTION 268500 – ELECTRIC HEATING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. All Sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL ELECTRIC HEAT REQUIREMENTS

- A. This section is intended to cover general materials and installation of electric heating systems and equipment applicable to Contractor's work.
- B. Contractor shall include labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Contract drawings and specifications are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Electric heating equipment specified in Divisions 23 and 26 shall be wired complete and ready for service by Contractor, except as otherwise noted.
- E. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part number listed in any of following paragraphs are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install the following electric heating equipment:
 - 1. Pipe Freeze Protection Equipment

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of the required electric heating equipment and devices.
 - 1. Pipe freeze protection heating cables shall be provided for hot and chilled water piping.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to following:
 - 1. Pipe freeze protection equipment

PART 2 - PRODUCTS

2.1 PIPE FREEZE PROTECTION EQUIPMENT

- A. General:
 - 1. The extent of piping to be traced with pipe freeze protection cable shall be as indicated on the plumbing and/or mechanical drawings.
 - 2. Contractor shall install pipe freeze protection cable in accordance with NEC.
 - a. Equipment leakage current interrupters (30 mA) shall be provided on branch circuits feeding the electric heating cable.
 - b. Heating cable shall have metal covering and shall be grounded.

B. Materials and Applications:

1. Self-Regulating Cable: Pipe freeze protection cable shall be self-regulating type 120 VAC pipe tracer. Pipe freeze protection cable shall be provided by only one manufacturer in accordance with following schedule for 1-1/2 inch fiberglass insulation with desired maintenance temperature of plus 40 deg. F. and minimum expected ambient temperature of -20 deg. F. Reference specifications Section 232500 - MECHANICAL INSULATION for insulation type and thickness for a specific piping system. For metal pipes required to have insulation other than 1-1/2 inch fiberglass insulation with the same desired maintenance temperature and minimum expected ambient temperature, provide freeze protection cable in accordance with manufacturer's design requirements. Unless otherwise indicated cable shall have braided tinned copper shield (CT) for ground path.

Type Tracing	Metal Pipe Size/ 1-1/2" Insulation	Thermal Rating Watts/Foot (*)	Max. Circ. Lgth. in Ft.	
			120 Volt @ 50° F 20 amp	240 Volt @ 50° F 20 amp
BTV Auto-Trace	3/8" through 2"	3 W/ft. (Po)	330	660
BTV Auto-Trace	2-1/2" through 4"	5 W/ft. (Po)	270	540
BTV Auto-Trace	6"	8 W/ft. (Po)	200	400
BTV Auto-Trace	8"	10 W/ft. (Po)	160	320
QTVR Auto-Trace	10" through 12"	10 W/ft. (F)	130	265
QTVR Auto-Trace	14" through 18"	15 W/ft. (F)	100	210
QTVR Auto-Trace	20" through 24"	20 W/ft. (F)	80	160

2. Tracing Insulation (*):

- a. (Po) Polyolefin 150 deg. F. max. maintained
- b. (F) Fluoropolymer 225 deg. F. max. maintained

- C. Accessories: Provide necessary components required to complete installation. Provide for each branch circuit one 20 amp outdoor thermostat with element sensing ambient air temperature. Thermostat shall be NEMA 4X construction and have set point of 40 deg. F. with 6 deg. F. differential. Provide end-of-line signal light in a weather-resistant enclosure at end of each pipe tracing run. Where pipe tracing branches out in several directions on same run, end-of-line signal light shall be provided at end of each branch run.
- D. Manufacturer: Manufacturer shall be Raychem Corp. (Trace) of Menlo Park, California or Nelson. All products shall be by single manufacturer.

PART 3 - EXECUTION

3.1 PIPE FREEZE PROTECTION EQUIPMENT INSTALLATION AND TEST

- A. Pipe tracing heating cable(s) and thermostat sensing element shall be installed prior to application of insulation. Pipe tracing installation shall be coordinated with respective contractor installing pipe or equipment being protected. Contractor shall verify exact circuit lengths in the field and shall make necessary adjustments in conduit, wire and circuit breaker size to meet the actual circuit length.
- B. Pipe tracing shall not be spiral wrapped unless specifically indicated by manufacturer's installation instructions. Tracing normally shall be installed in straight line on bottom quadrant of horizontal pipe runs as indicated by manufacturer.
- C. Removal: Valves, flanges and hangers shall be wrapped with additional pipe tracing and in such manner as to allow removal of these items without cutting heating cable. See manufacturer's installation sheets for specific instructions.
- D. Contractor shall provide items necessary for complete operating system. End-of-line signal lights shall be installed in visible location. Additional wire and conduit from end of heating cable runs shall be provided as necessary.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- E. Ground Fault CB: Piping freeze protection cables shall have branch circuits terminate on 30 mA equipment leakage current interrupter (ELCI) circuit breakers.
- F. Labels: "ELECTRIC TRACED" label shall be affixed to exterior of insulation at 10 ft. intervals. On short pipe tracing runs between 2 ft. and 10 ft. with heating cable at least one label shall be affixed.
- G. Pipe Freeze Protection Test:
 - 1. With pipe tracing installed, Contractor shall perform following test on pipe tracing one thermostat controlled circuit at a time. Tests shall be performed prior to Engineer's final observation. Malfunctions encountered during tests shall be corrected immediately by Contractor.
 - 2. Verify pipe freeze protection is correctly wired to branch circuit panelboard.
 - 3. Energize power to pipe tracing and adjust thermostat until tracing becomes energized.
 - 4. Verify pipe tracing radiates heat for one minute.
 - 5. Verify end-of-line pilot lights become energized.
 - 6. Reset thermostat to initial setting of 40 deg. F.

END OF SECTION 268500

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SECTION 270100 – BASIC COMMUNICATIONS REQUIREMENTS

PART 1 – GENERAL

1.01 RELATED WORK:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. If there is a conflict between the drawings and the specifications, the Contractor shall contact the Engineer for clarification.
- C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- D. All Division 27 Specifications apply to this section.

1.1 REFERENCES:

- A. All work shall be in compliance with the following codes and agencies. Nothing contained within these specifications shall be misconstrued to permit work not in conformance with the most stringent applicable codes and standards.
 - 2. National Electrical Code (NEC)
 - 3. National Fire Protection Association (NFPA)
 - 4. Federal, State, and Local Codes.
 - 5. National Electronic Manufacturer's Association (NEMA)
 - 6. Institute of Electronic Manufacturer's Association (IEEE)
 - 7. American National Standards Institute/Electronic Industries Association/Telecommunication Industries Association (ANSI/EIA/TIA)
- B. All materials, equipment, and installation practices shall meet or exceed the requirements of the following standards, unless specifically instructed otherwise by the Owner.
 - 2. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.0 – Commercial Building Telecommunications Cabling for Customer Premises.
 - 3. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.1 – Generic Telecommunications Cabling Standard.
 - 4. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standard
 - 5. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.3 – Optical Fiber Cabling Components Standard
 - 6. Telecommunications Industry Association /Electronic Industries Association TIA/EIA) 568-B – Commercial Building Telecommunications Wiring Standard
 - 7. TIA/EIA 569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
 - 8. ANSI/TIA/EIA 606-B – Administration Standard for Telecommunications Infrastructure of Commercial Buildings.
 - 9. ANSI/TIA/EIA 607-B –Commercial Building Grounding and Bonding Planning and Installation Methods for Commercial Buildings.
 - 10. ANSI/TIA/EIA 758-B – Customer-Owned Outside Plant Telecommunications Infrastructure Standard.
 - 11. TIA/EIA TSB-67 – Transmission Performance Specifications for Field Testing of Unshielded Twisted Pair Cabling Systems.
 - 12. TIA/EIA TSB-72 – Centralized Optical Fiber Cabling Guidelines.
 - 13. Underwriters Laboratories (UL) Cable Certification and Follow-up Program.
 - 14. National Electric Code (NEC) 2014 Current Edition.
 - 15. Institute of Electrical and Electronic Engineers (IEEE).

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

16. American National Standards Institute (ANSI) X3T9.5 Requirements for UTP at 100 Mbps
17. BICSI Telecommunications Distribution Methods Manual (TDMM) – 13th Edition, Current Edition.
18. BICSI Customer-Owned Outside Plant Design Reference Manual (OSP) – 5th Edition.

C. References to standards of organizations are made herein in accordance with the following abbreviations:

ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guideline
ANSI	American National Standards Institute Inc.
ASA	American Standards Association
ASTM	American Society for Testing and Materials
BICSI	Building Industry Consulting Service International, Inc.; Telecommunications Distribution Methods Manual (TDMM), Latest Edition, and Telecommunication Cabling Installation Manual, Latest Edition.
BOCA	Building Officials and Code Administrators International, Inc.
EIA	Electronic Industries Association
FCC	Federal Communications Commission
ICEA	Insulated Cable Engineers Association
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standard Organization
NEC	National Electrical Code (NFPA 70)
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NTSC	National Television Standards Committee
OSHA	Occupational Safety and Health Administration
TIA	Telecommunications Industry Association
UL	Underwriters Laboratories, Inc.

- D. Work installed shall be in strict compliance with governing codes and regulations. Installation shall be in accordance with installation recommendations and details provided by product manufacturers unless exceeded in quality by these specifications. Work called for in the specifications or shown on the drawings that is deemed contrary to the code by the local authority having jurisdiction governing shall be brought to attention of Engineer prior to installation for clarification or revision.

1.2 DEFINITIONS AND ABBREVIATIONS:

- A. Structured Cabling System (SCS): The SCS includes all components, installation, and testing required for a complete and warranted system to achieve a specified level of performance.
- B. Work Area (WA): The WA is the location that terminates the telecommunications outlet (data/voice) on the end of the horizontal cable system and then provides modular connectivity to devices.
- C. Equipment Room (ER)/Telecommunication Room (TR): The ER/TR provides space for the horizontal distribution equipment. It provides the link from the Backbone Distribution System to the Horizontal Distribution System. The Equipment/Telecommunication Room contains terminations, interconnections and cross-connections for telecommunications distribution cable.
- D. Horizontal Distribution System: The Horizontal Distribution System connects the Work Area to the ER/TR. The Horizontal Distribution System consists of the horizontal pathway and the horizontal cabling system. The horizontal pathways are used to distribute, support, and provide

access to the horizontal cabling system. The horizontal cabling system is the medium used for transporting telecommunications signals and consists of both cable and connecting hardware.

- E. The word "provide" as used on the plans and in these specifications shall be understood to mean all administration, labor, tools, materials and equipment required for a complete and operable installation of the referenced item, system and/or product.

1.3 GENERAL REQUIREMENTS:

- A. Submission of shop drawings will be considered as indicating that space requirements have been reviewed and that submitted equipment will fit space allocated with due concern given to access required for maintenance purposes and heat dissipation.
- B. Contract drawings and specifications are complementary and what is called for by one shall be binding as if called for by both.
- C. Contractor shall furnish and install all labor and material required to complete installation including accessories, fittings, auxiliaries, and components required for proper performance of systems.
- D. Location of Equipment and Devices:
 - 1. Location of the telecommunication equipment and devices shown are approximate. Determine the exact location of the equipment and devices by checking the Architectural drawings, field measurements, or the approved shop drawings.
 - 2. Relocate equipment or devices when directed by Engineer without cost, providing equipment has not been installed and the new location is not greater than 10 feet from the location shown.
- E. Quality Control:
 - 1. Exposed Work in Finished Spaces: Install telecommunication devices and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed.
 - 2. Equipment Access: Install telecommunication devices and equipment to facilitate servicing, maintenance and repair or replacement. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.
 - 3. Cleanliness: Contractor shall keep debris and dirt from around, on top of and the inside of all telecommunication equipment he provides during construction.

1.4 QUALITY ASSURANCE:

- A. Comply with NFPA 70. Comply with applicable local code requirements of the Authority having jurisdiction.
- B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

1.5 MATERIALS AND WORKMANSHIP:

- A. Material and equipment required under this contract shall be new unless otherwise specified. Workmanship shall be first class and be performed by persons qualified in respective trades.
- B. Material shall meet requirements of governing codes and regulations.
- C. UL Listing: Telecommunication material, equipment and systems, where applicable, shall be UL listed.

1.6 CONTRACTOR QUALIFICATIONS

- A. All contractors must meet these requirements to be considered qualified for installation:

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. The cable and hardware manufacturers of the cabling and hardware to be installed must certify contractor. The contractor must present proof of this certification in advance of bidding the contract.
2. Contractor will assign an on staff RCDD to the project. The RCDD will visit the job site at least twice a week to review work and schedules.
3. The contractor must be bonded and possess a valid state Contractor's License, issued at least 2 years prior to the date of this bid.
4. The selected low voltage installer shall provide a 25-year manufacturer warranty. This warranty shall include defects in materials and workmanship. The warranty period shall begin at the date of Engineer acceptance of the work. Quality and workmanship shall be evaluated by Owner and designated representatives only.
5. Contractor must be certified to install the cabling and termination materials they provide. A certificate verifying this certification must be submitted with the bid documents. Every technician who terminates a connection must be certified in that connectivity. A copy of certification for each technician must be submitted to Engineer prior to starting the project.

1.7 COORDINATION:

- A. Work Coordination: Coordinate work of this section with the security, audio/visual, and local area network (LAN) contractors and suppliers:
 1. Meet jointly with representatives of the above organizations and Owner's representatives to exchange information and agree on details of equipment arrangements and installation interfaces.
 2. Record agreements reached in meetings, and distribute record to other participants.
 3. Adjust the arrangements and locations of distribution frames, patch panels and cross-connect in telecommunication rooms to accommodate and optimize the arrangement and space requirements of the voice, data and video equipment.
- B. Coordinate work with other contractors and/or building elements to eliminate interferences. Interferences due to lack of coordination shall be corrected to provide proper clearance and access without additional compensation. Telecommunication equipment shall not be hung from piping or ductwork or from hangers supporting piping or ductwork. Install cable tray, conduit and boxes giving right-of-way where space is available to systems such as plumbing, drain and fire protection lines required to be installed at a specified slope.
- C. Adequate clearance shall be maintained to allow access, repairs and removal of equipment and devices. Protect installation of equipment or devices from being obstructed by other Contractors.
- D. Permanent openings or knockout panels shall be provided to permit future service or replacement of system components, but not necessarily for entry or exit of entire assembled units.
- E. Building structure is designed for supporting equipment at its permanent location. Provide necessary shoring or other protection necessary for moving heavy equipment to permanent location.

1.8 SITE OBSERVATION:

- A. Visit site prior to preparation of bid and determine conditions that affect execution of work. This includes but is not limited to exact locations of existing equipment, type supports, wire and conduit lengths, handholes, ceiling access and sleeves through existing smoke and fire partitions.
- B. Locations and elevation of existing underground facilities such as manholes, handholes, and poles, sewers, water piping, duct banks, cables, and conduits are as exact as can be determined

from available information and their accuracy cannot be guaranteed. Exact location and elevation of these services shall be verified by Contractor prior to excavation or installation of work. Exercise special care when excavating at or near the general location of underground utilities to avoid damage to utility services, as well as to assure safety. Existing services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.

- C. Connections to or relocation of existing utility lines requiring temporary discontinuation of services which are in active use shall be scheduled and coordinated with Utility companies and representatives of Owner. Premium time required for installation of connections and relocations shall be included in bid. Services shall not be left disconnected at end of working day or weekend unless authorized by representatives of Utilities and Owner.
- D. Failure to be acquainted with job site construction conditions under which work is to be performed will not be justified for additional compensation

1.9 MOUNTING AND LOCATIONS:

A. Location of Equipment and Devices:

- i. Locations of telecommunication equipment and devices shown are approximate. Determine exact location by checking field conditions and approved shop drawings.
- ii. Relocate equipment or devices provided under this contract when directed by Engineer without cost, provided equipment has not been installed and new location is not greater than 10 feet from location shown.
- iii. Wiring, signal and control devices, where provided, shall be flush-mounted in finished areas.

1.10 FINAL OBSERVATION:

- A. Reference Specification Section 017700 Closeout Procedures for additional information in regards to final observation.
- B. Contractor shall review requirements of Contract Documents, observe work and inform parties involved of work to be corrected or completed before project can be deemed substantially complete.
- C. Notify Engineer in writing, when project is substantially complete listing those items of work remaining incomplete and anticipated date that remaining work will be completed. Final observation of project will then be scheduled by Engineer.
- D. Engineer reserves right to cancel and re-schedule observation in event considerable more work remains to be completed or corrected than indicated in written request for observation.
- E. Items not completed or found not complying with drawings or specifications by Engineer will be identified in observation report by Engineer.
- F. Engineer will make final check after items have been corrected. Contractor shall be present during final check and shall verify that corrections have been made.

1.11 TESTING:

A. General:

- 1. Contractor shall be responsible for providing tests, and record of test to Engineer. Testing shall be performed by and under direct supervision of Contractor and shall be made only by qualified personnel fully experienced in this type of testing.
- 2. Contractor shall provide necessary test equipment. Checking of factory wiring and other preliminary work is preparing for telecommunication tests shall be responsibility of Contractor.

3. Tests shall be scheduled with Engineer and manufacturer's representative. Testing shall be during normal working hours unless otherwise indicated or specified.
4. Contractor shall correct faults, malfunctions or failures discovered during tests. Faulty equipment or devices shall be replaced with new equipment or devices provided by Contractor. Replaced equipment or devices shall be retested after replacement to verify their correct operation. When the equipment or device is part of a system, the system shall be retested to verify its correct operation.

B. Tests:

1. Test requirements are defined under each Division 27 specification section. Testing documents, schedules, templates, etc. shall be developed by the Contractor and submitted to the Engineer for review.

1.12 WARRANTY:

A. General Warranty:

1. Warranty work against defects in labor and material for period of one year from date of Final Acceptance.
2. Starting date of Warranty for defective or incomplete system or equipment shall become effective only after correction of defects and completion of systems or equipment.
3. Warranty period for systems or equipment will begin from date of Final Acceptance. Submit written certificate in triplicate listing such systems and equipment to Engineer for signature of Owner for record purposes.
4. Warranty is not intended to cover damage resulting from Owner's misuse or to cover normal maintenance.

- B. Provide extended manufacturer's warranty, for a minimum of 25 years from the date of occupancy, shall include providing replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s) for the period indicated above.**

PART 2 – PRODUCTS

2.1 Not applicable.

PART 3 – EXECUTION

3.1 Not applicable.

END OF SECTION 270100

SECTION 270528 – PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Metal wireways and auxiliary gutters.
 - 5. Nonmetallic wireways and auxiliary gutters.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 261300 "Raceways and Boxes" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.

1.3 DEFINITIONS

- A. EMT: Electrical metallic conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. RNC: Rigid nonmetallic conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures, cabinets and handholes. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Alpha Wire Company.
 - 4. Anamet Electrical, Inc.
 - 5. Electri-Flex Company.
 - 6. O-Z/Gedney; a brand of EGS Electrical Group.
 - 7. Wheatland Tube Company; a division of John Maneely Company.
- B. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Steel, set-screw type, die-cast fittings will not be allowed.
 - 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
- F. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Arnco Corporation.
 - 5. CANTEX Inc.
 - 6. CertainTeed Corp.
 - 7. Condux International, Inc.
 - 8. Electri-Flex Company.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. RACO; a Hubbell company.
 - 11. Thomas & Betts Corporation.
- B. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire Company.
 2. Arnco Corporation.
 3. Endot Industries Inc.
 4. IPEX.
 5. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum installation unless otherwise indicated.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Technologies Company; Cooper Crouse-Hinds.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman; a Pentair company.
 5. Hubbell Incorporated; Killark Division.
 6. Lamson & Sessions; Carlon Electrical Products.
 7. O-Z/Gedney; a brand of EGS Electrical Group.
 8. RACO; a Hubbell company.
 9. Robroy Industries.
 10. Spring City Electrical Manufacturing Company.
 11. Thomas & Betts Corporation.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-B.
 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

- E. Metal Floor Boxes:
 - 1. Material: Sheet metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Device Box Dimensions: Each work area outlet shall have a one, two, or four port faceplate over a 4 11/16 x 4 11/16" x 3" deep device box with a single gang device ring.
- H. Gangable boxes are prohibited.
- I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- J. Cabinets:
 - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 - 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Loading dock.
 - b. Mechanical rooms.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 5. Damp or Wet Locations: GRC.
 - 6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
 - 7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Plenum-type, optical-fiber-cable pathway.
 - 8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway.
 - 9. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.
- C. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. GRC: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
- D. Install surface pathways only where indicated on Drawings. Paint conduit to match finished surfaces.
- E. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with Division 26 requirements for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Pathways Embedded in Slabs:
1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 5. Change to Type EPC-40-PVC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
1. Use EMT or GRC for pathways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- O. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lbtensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- P. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- Q. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.
- R. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service pathway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- S. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground GRC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- T. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

- U. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- V. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- W. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- X. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- Y. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 27 0544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

END OF SECTION 270528

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SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. See Section 271100 Communications Equipment Room Fittings for cable runway for use inside Telecommunication Rooms.

1.2 SUMMARY

- A. Section Includes:
 - 1. Wire-basket cable trays.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of cable tray.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- C. Delegated-Design Submittal: For seismic restraints.
 - 1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.
 - 3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
 - 2. Vertical and horizontal offsets and transitions.
 - 3. Clearances for access above and to side of cable trays.
 - 4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
- B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 WIRE-BASKET CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cablofil Wire Mesh
 2. Chatsworth OnTrac Wire Mesh
 3. Cooper B-Line Flextray
- B. General: Provide wire basket of types and sizes indicated; with all required splicing and fill with applicable standards; and with the following additional construction features.
- C. Materials and Finishes: Material and finish specifications are as follows:
1. Pre-Galvanized Zinc: Straight section shall be made from pre-galvanized steel meeting the minimum mechanical properties of ASTM A641. Material must be cleaned after fabrication to remove any soot, manufacturing residue/oils, or metallic particles

2. All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be T-welded on all tray sizes.
3. Wire basket crosswire to be constructed with shaped wire to provide flat surface for cable support, avoiding pressure points or cable strain. Round wire construction allowed per engineers approval.
4. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4 inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.
5. Wire basket sizes shall conform to the following nominal criteria: Straight sections shall be furnished in standard 118 inch lengths. Wire diameter shall be 0.195" (5mm) minimum on all mesh sections up to 16 linear inches. Wire diameter linewire shall be 0.234" (6mm) minimum on all mesh sections in excess of 16 linear inches. Wire diameter shall be minimum size of 4.5mm on stainless steel.
6. Wire basket shall have a 4 inch usable loading depth by 24 inches wide, unless noted otherwise on drawings.
7. All fittings shall be field formed, from straight sections, in accordance with manufacturer's instructions.
8. All Tray sections and splicing assemblies shall be UL Classified as an Equipment Ground Conductor (EGC).
9. Special accessories shall be furnished as required to protect, support and install a wire basket support system.

2.4 WARNING SIGNS

- A. Lettering: 1-1/2-inch-high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."
- B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA FG 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA FG 1.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Join cable tray with splice plates; use four square neck-carriage bolts and locknuts.

- F. Fasten cable tray supports to building structure and install seismic restraints.
- G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb.
- H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- J. Support bus assembly to prevent twisting from eccentric loading.
- K. Locate and install supports according to NEMA FG 1. Do not install more than one cable tray splice between supports.
- L. Support wire-basket cable trays with center support hangers, trapeze hangers or wall brackets.
- M. Support center support hangers or trapeze hangers for wire-basket trays with 3/8-inch-diameter rods.
- N. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- O. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.
- P. Make changes in direction and elevation using manufacturer's recommended fittings.
- Q. Make cable tray connections using manufacturer's recommended fittings.
- R. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- S. Install cable trays with enough workspace to permit access for installing cables.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270540 "Communications Grounding and Bonding"
- B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with Velcro Straps according to NEMA VE 2. Tighten only enough to secure the cable, without indenting the cable jacket. Fasten cables on vertical runs to cable trays every 18 inches.
- C. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing cable trays survey for compliance with requirements.
 - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 3. Verify that the number and size of cables in cable trays do not exceed that permitted by NFPA 70. Verify that electrical (power) cables or conductors have not been installed in the communication cable tray.
 - 4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
 - 5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - 7. Check for improperly sized or installed bonding jumpers.
 - 8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
- B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

DOCUMENT 270540 - COMMUNICATIONS GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- C. Section 270100 Basic Communications Requirements
- D. Section 271100 Communications Equipment Room

1.2 REFERENCES

- A. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- B. Conflicts:
 - 1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
 - 2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.
- C. Underwriters' Laboratories (UL):
 - 1. 83 Thermoplastic Insulated Wire and Cables
 - 2. 96A System Installation
 - 3. 467 Grounding and Bonding Equipment
- D. National Fire Protection Association (NFPA):
 - 1. 70 National Electrical Code (NEC)
 - 2. NEC Article No. 250 - Grounding
- E. Telecommunications Industry Association/Electronic Industries Association (TIA/EIA):
 - 1. ANSI/TIA.EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications
- F. Building Industry Consulting Services International (BICSI):
 - 1. Telecommunications Distribution Methods Manual
- G. Local, County, State and Federal regulations and codes in effect as of date of purchase shall be complied with

1.3 SUBMITTALS

- A. Submit all required documents in accordance with defined Submittal Procedures
- B. Product Data:

1. Manufacturer's catalog data and applicable special fabrication and installation details
2. Installation, terminating and splicing procedures
3. Instructions for handling and storage
4. Dimensions and weights

1.4 QUALITY ASSURANCE

- A. Furnish products of latest proven design, new and in current production. Do not use obsolete components or out-of-production products
- B. Tests for Insulated Cable: Pass vertical tray flame test following IEEE 383-2.5

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Cable Manufacturers
 1. Anixter
 2. Cablec
 3. Okonite
- B. Exothermic Connector Manufacturers
 1. Burndy (Therm-O-Weld)
 2. Erico (Cadweld)
 3. Harger
- C. Grounding Connectors
 1. Burndy O.Z. Gedney
 2. Thomas & Betts
 3. Harger
 4. Panduit
- D. The list above is provided as a supplement and is not intended to exclude other manufacturers which meet or exceed the requirements listed herein

2.2 MATERIALS

- A. Grounding Conductors: Bare or insulated (green in color) copper AWG wire following ASTM-B3, ASTM-B8 and ASTM-B33, of following sizes:
 1. A minimum of 6 AWG, stranded copper conductor should be used for communications
- B. Grounding Connectors: It is recommended that connectors should be one of the following:
 1. Tin-plated copper
 2. Copper

3. Copper alloy
- C. Where single conductor insulated grounding conductors are required, furnish insulation, green in color (or tape marking), rated for 600 volts
- D. Telecommunications Main Grounding Busbar (TMGB):
 1. The TMGB shall be a predrilled copper busbar with standard BICSI bolt hole sizing and spacing for the type of connectors to be used
 2. The TMGB shall be sized for the immediate requirements and allow for growth
 3. The minimum dimensions are 6 mm thick x 100 mm wide x 20" Long.
 4. The busbar should be electro tin plated for reduced contact resistance
- E. Telecommunications Grounding Busbar (TGB):
 1. The TGB shall be a predrilled copper busbar with standard BICSI bolt hole sizing and spacing for the type of connectors to be used
 2. The TGB shall be sized for the immediate requirements and allow for 100% growth
 3. The minimum dimensions are 6 mm thick x 50 mm wide x 12" Long.
 4. The busbar should be electro tin plated for reduced contact resistance

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify exact location of stub-up points for grounding of equipment, fences and building or steel structures
- B. Copper and copper alloy connections should be cleaned prior to connection
- C. In new construction, the electrical contractor must provide accessible means to a direct electrical service ground, which is one of the best points for grounding communications systems. NEC Section 250-71(b) requires an intersystem bonding connection accessible at the electrical service equipment, such as:
 1. Approved external connection on the power service panel. The NEC allows direct connection to a provided 6 AWG copper conductor
 2. Exposed metallic service raceway (using an approved bonding connector)
 3. Grounding electrode conductor

3.2 INSTALLATION

- A. Install work following drawings, manufacturer's instructions and approved submittal data
- B. Bonding conductors shall be routed with minimum bends or changes in direction and should be made directly to the points being bonded
- C. Bonding connections should be made by using:
 1. Bolt connectors, clamps, or lugs. Use listed hardware that has been laboratory tested to eliminate most field problems

2. Exothermic welding (see NEC Section 250-81) within the ground electrode system, for parts of a grounding system that are subject to corrosion or that must carry high currents reliably, or for locations that require minimum maintenance
- D. Telecommunications Raceway and Support Systems Grounding:
1. Bond and ground raceway, cable rack or tray and conduit together and permanently ground to the equipment grounding busbar. Connection to conduit may be with grounding bushing or ground clamp
 2. Connect cable tray to grounding electrode system. Telecommunications cable tray that is located in the same room as the TMGB shall be connected to the TMGB
 3. Where a grounding conductor is run in or on a cable tray, bond grounding conductors to each section of cable tray with a cable tray ground clamp
 4. Where only grounding conductor is installed in a metal conduit, bond both ends of conduit to grounding conductors
 5. Provide flexible "jumpers" around raceway expansion joints and across cable tray joints parted to allow for expansion and hinged cable tray connections. Provide copper bonding straps for steel conduit
- E. Telecommunications Grounding and Bonding Infrastructure:
1. Install the TMGB in the MDF Room. The TMGB should also be located so that the bonding conductor is as short and straight as possible. Maintain clearances required by applicable electrical codes
 2. If a panelboard is not installed in the MDF Room, locate the TMGB near the backbone cabling and terminations.
 3. The TMGB shall be insulated from its support with a recommended separation of 2 inches
 4. Connect the TMGB to the main electrical service ground for the building and telecommunications primary protectors
 5. The minimum Telecommunications Bonding Backbone (TBB) conductor size shall be No. 6 AWG. The TBB originates at the TMGB and extends throughout the building using the telecommunications backbone pathways, and connects to the TGB(s) in all telecommunication closets and data rooms
 6. Install the TGBs in the telecommunications closets and data rooms as close to the panel board as possible. The TGB should also be located so that the bonding conductor is as short and straight as possible. Maintain clearances required by applicable electrical codes. The TGB shall be insulated from its support with a recommended separation of 2 inches
 7. Properly bond and ground all communications cabinets, equipment racks, raceway, cable rack or tray, and conduit together and permanently ground to the TGB

3.3 IDENTIFICATION

- A. Grounding system components shall be labeled twelve (12) inches from each end of the Telecommunications Bonding Conductor (TBC) and every ten (10) feet where exposed
- B. Label all equipment grounding conductors to indicate the rack and panel being grounded and the ground bar to which the TBC is connected

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. All TBC's in the building, including, but not limited to, those connecting building steel, grounding electrodes, water pipes, radio towers, and telecommunications structural components shall be labeled

3.4 TESTING

- A. Test grounding system per testing requirements defined in ANSI/TIA.EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
- B. The contractor shall notify the owner prior to testing the grounding system. At the Owner's discretion, the Owner may require that an Owner's Representative be present for a portion of or the entire testing process
- C. Within 10 days of completion of testing of the grounding system, all test documentation shall be submitted to the Engineer for review

END OF SECTION 270540

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SECTION 270800 – CABLE TESTING AND ADMINISTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Related Documents: Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to the work of this section.
- B. Section 270100 Basic Communications Requirements.
- C. Section 271300 Backbone Cabling Requirements.
- D. Section 271500 Horizontal Cabling Requirements.

1.2 REFERENCES

- A. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- B. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean the latest printed edition of each in effect at the date of contract unless the document is shown dated.
- C. Conflicts:
 - 1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
 - 2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.
- D. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.0 – Commercial Building Telecommunications Cabling for Customer Premises.
- E. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.1 – Generic Telecommunications Cabling Standard.
- F. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standard
- G. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.3 – Optical Fiber Cabling Components Standard
- H. Telecommunications Industry Association /Electronic Industries Association (TIA/EIA) 568B – Commercial Building Telecommunications Wiring Standard
- I. TIA/EIA 569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- J. ANSI/TIA/EIA 606-B – Administration Standard for Telecommunications Infrastructure of Commercial Buildings.

- K. ANSI/TIA/EIA 758-B – Customer-Owned Outside Plant Telecommunications Infrastructure Standard.
- L. TIA/EIA TSB-67 – Transmission Performance Specifications for Field Testing of Unshielded Twisted Pair Cabling Systems.
- M. TIA/EIA TSB-72 – Centralized Optical Fiber Cabling Guidelines.

1.3 DEFINITIONS

- A. ACR-F - Attenuation -to-Crosstalk Ratio-Far End
- B. ACR-N - Attenuation -to-Crosstalk Ratio-Near End
- C. AWG – American Wire Gauge
- D. AXT – Alien Crosstalk
- E. BICSI – Building Industry Consulting Services International
- F. Mbps – Megabits per Second
- G. OTDR – Optical Domain Reflectometer
- H. PVC – Polyvinyl Chloride
- I. RCDD – Registered Communications Distribution Designer
- J. TDR - Time Domain Reflectometer
- K. TSB – Technical Systems Bulletin.
- L. NEXT – Near End Crosstalk.
- M. FEXT – Far End Crosstalk.
- N. ELFEXT – Equal Level Far End Crosstalk.
- O. PSELFEXT – Power Sum Equal Level Far End Crosstalk.

1.4 SUBMITTALS

- A. Submit all documentation in accordance with Specification 270100 Basic Communications Requirements and requirements stated within this Section.
- B. Manufacturer's data for all proposed equipment and materials.
- C. List of termination and test equipment to be used for Contractor to perform work

1. Equipment shall be calibrated with trace ability to National Institute of Standards and Testing (NIST) requirements.
 2. Contractor shall include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- D. Testing Plan.
- E. All members of the installation team must be certified by the manufacturer as having completed the necessary training to complete their part of the installation. Resumes of the entire team shall be provided along with documentation of completed training courses.
- F. Certified test reports of the Contractor performed tests. Copies of the Contractor performed tests shall be submitted within one week of completion of tests. Test equipment and procedures shall conform to manufactures requirements to obtain warranty. Each set of test results will be reviewed by the Owner's representative for a maximum of two times for completion. In the event that the test results are not acceptable upon the second review, the contractor shall be responsible for any cost incurred to the Owner for further review.

PART 2– PRODUCTS

2.1 LABELS AND LABELING EQUIPMENT

- A. Labels for cabling, termination equipment, outlets and racks shall be machine-generated labels. Handwritten labels shall not be accepted.
- B. Permanent material pre-printed with black on white, with adhesive backing. Brady, 3M, or equal. No Dymo-tape or hand-written labels will be allowed. For use at the following locations:
1. Telecommunication outlet faceplates
 2. Individual horizontal cables
 3. Rack-unit (RU) identification of telecommunications room equipment racks
 4. Fiber optic distribution unit (FODU)

PART 3- EXECUTION

3.1 ACCEPTABLE ATTENUATION VALUES

- A. The general attenuation equation for any link segment is as follows:
1. $\text{Link Attn.} = \text{Cable Attn.} + \text{Connection Attn.} + \text{Splice Attn.}$
 2. Note: A connection is defined as the joint made by mating two fibers terminated with remateable duplex LC connectors.

3.2 8. μM SINGLEMODE ATTENUATION COEFFICIENTS

1. $\text{Cable Attenuation} = \text{Cable Length (km)} \times (1.0 \text{ dB/km@1310nm or } 1.0 \text{ dB/km@1550nm}).$

2. Connection Attenuation (LC connectors) = .50 dB per connector pair.
 3. Fusion Splice Attenuation = Splices $\times$ 0.20 db.
- B. Note: If lower maximum attenuation values are specified by the chosen manufacture, then the contractor is responsible for meeting those maximum attenuation values specified by the manufacture.

3.3 TESTING CATEGORY 6A

A. General

1. Contractor shall be responsible for providing tests, and record of test to Architect/Engineer and Owner. Testing shall be performed by and under direct supervision of Contractor and shall be made only by qualified personnel fully experienced in this type of testing.
2. Contractor shall provide necessary test equipment. Checking of factory wiring and other preliminary work is preparing for telecommunication tests shall be responsibility of Contractor.
3. Tests shall be scheduled with Architect/Engineer and manufacturer's representative. Testing shall be during normal working hours unless otherwise indicated or specified.
4. Contractor shall correct faults, malfunctions or failures discovered during tests. Faulty equipment or devices shall be replaced with new equipment or devices provided by Contractor. Replaced equipment or devices shall be retested after replacement to verify their correct operation. When the equipment or device is part of a system, the system shall be retested to verify its correct operation.
5. Reference to other Sections of Division 27 for additional testing requirements.
6. All cables shall be tested in accordance with this document, the ANSI/TIA standards, the Manufacturer's Certification Program and best industry practice. If any of these are in conflict, the Contractor shall bring any discrepancies to the attention of the project team for clarification and resolution. The field test equipment shall meet the requirements of ANSI/TIA -568-C including applicable TSB's and amendments. The appropriate Level III tester shall be used to verify Category 6A cabling systems. The test protocols: testing approach and equipment will be contained in the test results documents.
7. Printouts generated for each cable by the wire (or fiber) test instrument shall be submitted as part of the documentation package.
8. All test results shall be in the original tester format from applicable testers.
9. Results of each test component will be documented and presented to the Engineer and Owner, in electronic format, for review within five (5) business days of the completion of each test component.
10. Contractor will be required to perform corrections as may be required; vendor is required to perform a comprehensive test as detailed for each component within five (5) business days of initial failed inspection and provide Engineer and Owner with written results of the remedy solution and results. When repairs and re-tests are performed, the problem found

and corrective action taken shall be noted, and both the failed and passed test data shall be documented in detail.

B. Copper Channel Testing

1. All twisted-pair copper cable links shall be tested for continuity, pair reversals, shorts, opens and performance as indicated below. Additional testing is required to verify Category performance.
2. Horizontal cabling shall be tested using a Level III test unit for Category 6A performance compliance.
3. The basic tests required are:
 - a) Wire Map
 - b) Length
 - c) Insertion Loss (Attenuation)
 - d) NEXT (Near end crosstalk)
 - e) PSNEXT (Power sum near-end crosstalk loss)
 - f) ACR-F Loss
 - g) PS ACR-F Loss
 - h) Return Loss
 - i) Propagation Delay
 - j) Delay skew
4. Continuity - Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs and split pairs. Shielded/screened cables shall be tested with a device that verifies shield continuity in addition to the above stated tests. The test shall be recorded as pass/fail as indicated by the test unit in accordance with the manufacturers' recommended procedures, and referenced to the appropriate cable identification number and circuit or pair number. Any faults in the wiring shall be corrected and the cable re-tested prior to final acceptance.
5. Length - Each installed cable link shall be tested for installed length using a TDR type device. The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate. The cable length shall conform to the maximum distances set forth in the ANSI/TIA-568-C Standard. Cable lengths shall be recorded, referencing the cable identification number and circuit or pair number. For multi-pair cables, the shortest pair length shall be recorded as the length for the cable.
6. Category 6 Performance: Each cable shall meet the channel requirements outlined below for a 100-meter, 4-connector channel.

FREQ (MHZ)	MAXIMUM INSERTION LOSS (DB)	MINIMUM NEXT (DB)	MINIMUM PSNEXT (DB)	MINIMUM ELFEXT (DB)	MINIMUM PSELFEX T (DB)	MINIMUM RETURN LOSS (DB)	MINIMUM ACR (DB)	MINIMUM PS ACR (DB)
1	2.1	74.3	72.3	67.8	64.8	20.0	72.2	70.2
4	3.8	65.3	63.3	55.8	52.8	23.0	61.5	59.5
8	5.3	60.8	58.8	49.7	46.7	24.5	55.4	53.4
1	5.9	59.3	57.3	47.8	44.8	25.0	53.4	51.4
16	7.5	54.8	54.2	43.7	40.7	25.0	48.8	46.8
20	8.4	53.3	52.8	41.8	38.8	25.0	46.4	44.4

25	9.4	51.9	51.3	39.8	36.8	24.3	44.0	42.0
31.25	10.5	41.9	49.9	37.9	34.9	23.6	41.4	39.4
62.5	15.0	47.4	45.4	31.9	28.9	21.5	32.4	30.4
100	19.1	44.3	42.3	27.8	24.8	20.1	25.2	23.2
155	24.1	41.4	39.4	24.0	21.0	18.8	17.4	15.4
200	27.6	39.8	37.8	21.8	18.8	18.0	12.2	10.2
250	31.1	38.3	36.3	19.8	16.8	17.3	7.3	5.3
300	34.3	37.1	35.1	18.3	15.3	16.8	2.9	0.9
400	40.1	35.3	33.3	15.8	12.8	15.9		
500	45.3	33.8	31.8	13.8	10.8	15.2		

7. In addition to testing the "In-link" performance parameters detailed above, Alien Crosstalk testing or "Between-link" testing shall be carried out in accordance with Section 4.7 of ANSI/TIA-1152. Alien crosstalk testing includes the PS ANEXT and PS AACR-F (Power sum alien attenuation-to-crosstalk ratio from the far end) performance parameters. The standards refer to the link-under-test for Alien Crosstalk as the disturbed link.
8. Alien Crosstalk testing shall be performed using a sampling plan. An acceptance quality level (AQL) of 0.4 %, normal inspection, general inspection level I as defined in ISO 2859-1 for populations of up to 500,000 links shall be used. The following table represents this sampling level.

Installation size (No. of total links)	Sample size (No. of links to test)
3 – 33	100%
34 – 3,200	33
3,201 – 35,000	126
35,001 – 150,000	201
150,001 – 500,000	315

Disturbed (Victim) links chosen for Alien Crosstalk testing shall be an equal combination of short, medium and long links.

3.4 LARGE CABLE COUNT TEST RESULTS

A. Manufacturer's Testing

1. Copper Cable Testing.
2. Testing of all copper wiring shall be performed prior to system cutover. 100 percent of the horizontal wiring pairs shall be tested for opens, shorts, polarity reversals, transposition, and presence of AC voltage. The Category 3 riser cable runs shall be tested for conformance to the specifications of TIA/EIA 568B Category 3.
3. At a minimum, the Owner or their designated representative shall randomly perform unannounced, on-site reviews during the installation. In addition, this person shall perform a final inspection and a complete review of the test results before the installation is accepted.

4. The multi-pair copper cables shall meet the following specifications:

B. Physical Specification:

Gauge	24 AWG
Pair Size	25 to 1800

C. Electrical Specifications:

1. The non-shielded, plenum cable shall consist of 24-AWG solid-copper conductors insulated with color-coded PVC. 100 to 400 pair cable shall be conformance tested to meet TIA/EIA 568A for Category 3 cables. The cable shall be UL® and c (UL®) Listed for Fire Safety and ISO 9001 Certified. The non-shielded cable shall be available in 100, 200, 300, and 400 pair. The copper cable shall meet or exceed the following electrical specifications listed below:

Maximum DC Resistance	28.6 Ω /1,000 ft (9.38 Ω /100m)
Maximum DC Resistance Unbalanced	5%
Maximum Capacitance Unbalanced (pair to ground)	1,000 pF/1000 ft. (328 pF/m)
Mutual Capacitance @ 1kHz	16 nF/1000 ft (5.2 nF/100 m), maximum

D. Attenuation (dB/100 m [328 ft.])

Frequency	Attenuation (Max.)
1.00 MHz	7 dB
4.00 MHz	15 dB
10.00 MHz	26 dB
16.00 MHz	35 dB

E. Worst Pair Near-End Crosstalk (NEXT) dB/100 meters [328 feet]

Frequency	Pair-To-Pair NEXT
1.0 MHz	41 dB
4.0 MHz	32 dB
10.0 MHz	26 dB
16.0 MHz	23 dB

- F. The non-shielded, cable shall consist of 24-AWG solid-copper conductors insulated with color-coded PVC. 25 to 1800 pair cable shall be conformance tested to meet TIA/EIA 568A for Category 3 cables. The cable shall be UL® and c (UL®) Listed for Fire Safety and ISO 9001 Certified. The non-shielded cable shall be available in 25, 50, 75, 100, 200, 300, 600, 900, and 1800 pair. The copper cable shall meet or exceed the following electrical specifications listed below:

Maximum DC Resistance	28.6 Ω /1,000 ft (9.4 Ω /100m)
Maximum DC Resistance Unbalanced	5%
Maximum Capacitance Unbalanced (pair to ground)	1,000 pF/1000 feet. (328 pF/meters)
Mutual Capacitance @ 1kHz	18 nF/1000 ft (5.9 nF/100 m), maximum

- G. Attenuation (dB/100 m [328 feet.])

Frequency	Attenuation (Max.)
1.00 MHz	2.3 dB
4.00 MHz	4.9 dB
10.00 MHz	8.5 dB
16.00 MHz	12 dB

- H. Worst Pair Near-End Crosstalk (NEXT) dB/100 meters [328 feet]

Frequency	Pair-To-Pair NEXT
1.0 MHz	13.8 dB
4.0 MHz	11.2 dB
10.0 MHz	10.2 dB
16.0 MHz	9.2 dB

3.5 OTDR REQUIREMENTS

A. Optical Fiber Cable Testing w/ OTDR

1. To promote efficient and accurate testing:
 - a. Test jumpers should be factory assembled, factory polished, and the same optical fiber core size as the cabling system (e.g., 8.3/125 μ jumpers for a 8.3/125 μ system).
 - b. The power meter and the light source must be set to the same wavelength.
 - c. The power meter must be calibrated and traceable to the National Institute of Standards and Technologies or the applicable equivalent.
 - d. The light source should be LED based and encircled flux compliant per the International Electromechanical Commission (IEC) and the Telecommunications Industry Association (TIA) standards (IEC 61280-4-1 and ANSI/TIA-526-14-B).
 - e. The light source or OTDR must operate within 1310 $\pm$ 10 nm or 1550 $\pm$ 20 nm for singlemode testing.

- f. All system connectors, adapters, and jumpers must be cleaned before measurements are taken.
2. Polarity must be verified to ensure that the transmitter is connected to the receiver on the opposite end. Array connector polarity must be verified to ensure the consistency of the polarity method used.
3. All fiber testing shall be performed on all fibers in the completed end to end system. There shall be no splices unless clearly defined in an RFP. Testing shall consist of an end to end power meter testing performed per ANSI/TIA568-C.3. Singlemode measurements shall be provided at 1310 nm and 1550 nm.
4. All fiber testing shall be performed on all fibers in the completed end to end system. Testing shall consist of a bidirectional end to end OTDR trace performed per TIA/EIA 455-61. The system loss measurements and cable length shall be provided at 1310 and 1550 for single mode fibers. The OTDR shall be used only to determine the length of the cable and the attenuation of that cable. A power meter shall be used to determine the overall link attenuation, including connectors.
5. Fiber Optic Cables shall have a maximum loss of: $(\text{allowable cable loss per km}) \times (\text{km of fiber in link}) = \text{maximum allowable loss}$.
6. Loss numbers for the installed link shall be calculated by taking the sum of the bidirectional measurements and dividing that sum by two. The acquired loss statement shall be for the cable only and shall not include the connectors as part of the calculated loss.
7. Any link not meeting the requirements of the standard shall be brought into compliance by the Contractor, at no charge to the Owner.
8. Documentation shall be provided in both hard copy and on a CD-ROM to the point of contact.

3.6 LIGHT METER AND SOURCE

A. Optical Fiber Cable Testing w/ Power Meter

1. Single-mode Inter-Building and Composite Link Segments shall be tested in both directions at both 1310-nm and 1550-nm wavelengths, unless warranty requires bi-directional testing.
2. Fiber links shall have a maximum loss of: $(\text{allowable cable loss } .4 \text{ dB per km}) \times (\text{km of fiber in link}) + (.50 \text{ dB per connector pair}) + (.2 \text{ dB per fusion splice}) = \text{Maximum Allowable Loss}$.

Note: The minor attenuation differences due to test direction are on par with the accuracy and repeatability of the test method. Therefore, testing in only one direction is warranted, unless warranty requires bi-directional testing.

3.7 TEST RESULTS

A. Horizontal Copper Cabling

1. The Contractor shall test all cables and submit all horizontal copper cable test result data in electronic format, with the resulting file formatted with one test result per 8.5"x 11"

page.

2. Horizontal copper cabling test reports shall include the following information for each cabling element tested:
 - a) Wiremap results that indicate the cabling has no shorts, opens, miswires, split, reversed, or crossed pairs, and end to end connectivity is achieved.
 - b) Attenuation, NEXT, PSNEXT, Return Loss, ELFEXT, and PSELFEXT data that indicate the worst case result, the frequency at which it occurs, the limit at that point, and the margin. These tests shall be performed in a swept frequency manner from 1 MHz to 250 MHz, using a swept frequency interval that is consistent with TIA and ISO requirements. Information shall be provided for all pairs or pair combinations and in both directions when required by the appropriate standards. Any individual test that fails the relevant performance specification shall be marked as a FAIL.
 - c) Length (in meters), propagation delay, and delay skew relative to the relevant limit. Any individual test that fails the relevant performance specification shall be marked as a FAIL.
 - d) Cable manufacturer, cable model number/type, and NVP.
 - e) Tester manufacturer, model, serial number, hardware version, and software version.
 - f) Circuit ID number and project name. Circuit ID shall be the same ID used for labeling of cable and patch panel ports.
 - g) Autotest specification used.
 - h) Overall pass/fail indication.
 - i) Date of test.
 - j) Test Failures: Any cable that repeatedly fails the testing requirements as outlined by these specifications after all trouble shooting means have been exhausted shall be replaced with a second cable. Acceptable trouble shooting criteria include but are not limited to replacing connectors and/or patch cables.

B. Singlemode Fiber Optic Cabling

1. The Contractor shall test all fiber optic cables and submit all fiber test result data in an electronic format and provide one (3) hard copies of the test results showing graphically, the entire length of the fiber.
 - a) Reports shall show circuit ID, cursor marks, total attenuation, date of installation and test used.
 - b) Contractor shall submit (3) copies of software capable of viewing the electronic test result files.

3.8 LABELING

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- A. Cable, outlet and patch panel labeling shall conform to the following scheme:
1. Labels shall provide an indication of a data or voice termination – telecomm room identifier - patch panel identifier - room number - station number. Station number shall be determined by a count beginning at the door to the room, and counting counterclockwise.
 2. Example: The first data jack in Webster Hall Room 251 would be labeled D-WH2W-A1-251-1. The second D-WH2W-A1-251-2 and so on. The first voice jack (non-VOIP) in room 251 would be labeled V-WH2W-A1-251-1. The second V-WH2W-A1-251-1 and so on.
 3. The above referenced labeling scheme is for placement on the drop at the station end and NOT at the patch panel. The patch panel shall be labeled as D-251-1 if it is a data drop or V-251-1 if it is a voice drop.
 4. Patch panels in the rack should be labeled from top to bottom as A, B, C, D etc. If there is more than one rack in a telecomm room, the rack on the left or in the front row will start from top to bottom with A, B, C, D, etc. The rack on the right or behind will continue where the other rack ended. E, F, G etc.
 5. Webster University will determine the telecomm room identifier. Contractor shall contact the Webster University IT Department before beginning labeling to find out the network closet identifier being applied to a particular network closet.
- B. Contractor shall submit a labeling scheme document as part of the shop drawing submittal for final review and approval.
- C. All labeling must be provided in pdf or xls format upon project completion. Labeling must be listed in order by patch panel, separated by network closet.
- D. Cable test results must use the exact same labeling scheme as installed in the field. Test reports that do not reflect the same scheme will be rejected and tests reports will be redone at the Contractor's expense.

END OF SECTION 270800

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SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 27 Sections apply to this section.
- C. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.

1.2 SUMMARY

- A. Section Includes:
 - 1. Telecommunications mounting elements.
 - 2. Backboards.
 - 3. Telecommunications equipment racks and cabinets.
 - 4. Cable Runway
 - 5. Power Distribution Units
 - 6. Grounding.

1.3 REFERENCES

- A. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- B. Conflicts:
 - 1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
 - 2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.

1.4 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. LAN: Local area network.
- C. RCDD: Registered Communications Distribution Designer.

1.5 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - 3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS FOR EQUIPMENT FRAMES (RACKS)

- A. Ortronics/Legrand

2.2 APPROVED MANUFACTURERS FOR PDU (POWER STRIPS)

- A. APC
- B. Tripp-lite
- C. Owner approved equal

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Verify all interior communications pathways and spaces are installed in accordance with local Seismic requirements.

2.4 BACKBOARDS

- A. Backboards: Fire-rated plywood, 3/4 by 48 by 96 inches, AC Grade, Void Free, Fire Rated Backboard. Backboard shall be painted with fire retardant paint on ALL six (6) sides of the board. Label depicting fire rating of board shall NOT be painted over and shall be visible on each board installed.
- B. Provide backboards on all four (4) walls of the MDF Room and all Data Rooms. Backboard shall be started 12" AFF and extend the full height of 96".

2.5 EQUIPMENT FRAMES AND RACKS

- A. General Frame Requirements:
 - 1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Module Dimension: Width compatible with EIA 310-D standard, 19-inch panel mounting.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
- B. Open Frame Equipment Racks
 - 1. 2-post channel data rack, steel construction
 - 2. Vertical and horizontal cable management channels, top and bottom cable troughs
 - 3. Hole pattern shall meet EIA-310D on both the front and rear of rack.
 - 4. Baked-polyester powder coat black finish.
 - 5. Racks shall be rated for 2000 lbs load rating, minimum.
 - 6. The assembled rack shall measure 86" high x 23.75" wide x 16.5" deep and provide 45 rack units (RU) of mounting space.
 - 7. Furnish and install all necessary hardware for mounting equipment racks. Racks shall be securely mounted at the top and bottom.
 - 8. Furnish and install a solid copper ground bar at the topmost RU position. Ground bar shall not take up more than one (1) RU.
 - 9. Provide a power distribution (PDU) strip in all racks.
 - 10. See drawings for additional rack requirements.
 - 11. Provide rack by Ortronics, Part #OR-MM20706-B.
- C. Cable Management for Equipment Frames:
 - 1. Metal, with integral wire retaining fingers.
 - 2. Baked-polyester powder coat finish.
 - 3. 6.5" wide with removable covers.
 - 4. Vertical cable management shall be provided on both sides of the rack and shall have front and rear channels. Provide vertical wire manager by Ortronics, Part # MM20VMD706-B.
 - 5. Provide horizontal cable manager under each patch panel (copper and fiber) at the top of each relay rack, with a minimum height of two rack units each. Provide horizontal wire manager by Ortronics, Part #OR-MM6HMF1RU.

2.6 CABLE RUNWAY

- A. Cable runway shall be installed inside Telecommunication Rooms only and shall be used to support cabling to and between equipment racks located in the Telecommunication Room.
- B. Cable runway shall be manufactured from 3/8" wide by 1-1/2" high tubular steel with .065" wall thickness.
- C. Cable runway (side stringers) shall be 9'-11 1/2" long. Cross members shall be welded in between stringers on 12" intervals/centers beginning 5-3/4" from one end so that there are 10 cross members per cable runway. There shall be 10-1/2" of open space in between each cross member.
- D. Cable runway shall be delivered individually boxed, and available in the width(s) as specified on the drawings.
- E. Cable runway shall be UL Classified for suitability as an equipment grounding conductor only. Contractor shall remove paint or use ground straps at splices and intersections.
- F. Finish shall be epoxy-polyester hybrid powder coat (paint), black in color.
- G. Cable Runway Splices
 - 1. Splice kits shall provide a method of mechanically connecting cable runway sections and turns together end-to-end or side-to-end to form a continuous pathway for cables.
 - 2. Grounding kits shall provide a method of bonding cable runway sections and turns together that is independent of the pathway splices. The grounding kit should be constructed of UL Listed components. The preferred solution is a #6 AWG green insulated stranded copper conductor connected on both ends to cable runway using two-hole compression lugs and stainless steel hardware.
 - 3. An insulator bar kit shall provide a means of electrically isolating individual cable runway sections through an end-to-end splice separated with a non-conductive material. The preferred solution is a 3/8" (9.5 mm) wide by 1-1/2" (38 mm) high by 5-1/2" (140 mm) long insulator bar made of Delrin® (by DuPont, Delrin is a registered trademark of E.I. du Pont de Nemours and Company).
 - 4. Splices (splice plates) shall be manufactured from steel. Splice, grounding and insulator bar kits shall include installation hardware.
- H. Cable Runway Supports
 - 1. Supports shall be sized to match the width of the cable runway that is supported.
 - 2. Each support shall include a means of mechanically securing cable runway to the support.
 - 3. Supports shall be manufactured from steel or aluminum.
- I. Cable Runway Accessories
 - 1. Cable straps used for attaching cable bundles to the cable runway cross members must be reusable with a hook and loop-style closure, at least 3/4" wide, and sized for cable bundles that are 2", 3" or 4" in diameter.
 - 2. Cable retaining posts used to keep cable from falling off of the side of the cable runway shall be manufactured from 1" by 1/2" tubular steel with .065" wall thickness. Cable retaining posts shall be 8" high and shall attach to the side stringer of the cable runway

- with included hardware. The top of the cable retaining posts shall be fitted with a rubberized end cap to protect cables.
3. End caps used to cover the ends of cable runway shall be manufactured from a black fire-retardant rubberized material. End caps shall be sized for 3/8" wide by 1-1/2" high side stingers and shall be sold in pairs.
 4. End closing kits used to cover the end of cable runway shall be manufactured from 3/8" wide by 1-1/2" high tubular steel with .065" wall thickness. Kits shall consist of a bar cut to match the width of the cable runway and the hardware required to attach the bar to the end of a length of cable runway.
 5. Provide radius drops at all locations where cable enters or exits the runway. Radius drops shall be manufactured from aluminum extrusion. The extrusion shall be formed in a 90° arc with a minimum bend radius of 3". Radius drops shall attach to either the side stringer or the cross member of the cable runway using a clevis pin. Radius drops shall include 1-1/2" high cable spools that attach to the top of the radius drop to guide cables.
 6. Movable cross members used to support cross member radius drops in between welded cross members on cable runway shall be manufactured from 3/8" by 1-1/2" aluminum bar. Movable cross members shall attach to cable runway at the side stringers with included hardware so that the location of the movable cross member can be adjusted. Moveable cross member shall support a cross member radius drop.
 7. Auxiliary support brackets used to support cables that should be physically separated from the cables in the cable runway shall be made from 1/8" by 1" steel bar. The bracket shall be L-shaped and will attach to the side stringer of the cable runway. The bracket shall hang below the cable runway a minimum of 4". The bracket support surface shall be 4" long. The bracket shall be zinc plated with a gold chem. finish.
 8. Unless otherwise noted, finish on all metal components shall be epoxy-polyester hybrid powder coat (paint), black in color. Hardware shall be zinc plated with a gold chem. finish.

2.7 POWER DISTRIBUTION UNITS (PDU)

- A. Basic Horizontal PDU
 1. Horizontal power strip, 20A, 120V, 10 NEMA 5-20 receptacles, two 20A thermal breakers, and 12' power cord with NEMA L5-30 Plug, UL and c-UL Listed. Dimensions 1.75" H x 17.60" W x 2.25" DP, Black.
 2. The power strip shall be equipped with a bracket that enables it to be mounted on a 19" rack, or cabinet without modifications.
 3. Provide PDU by APC, Part #AP9560 or Owner approved equal.

2.8 GROUNDING

- A. Provide a horizontal ground bar at the top of each equipment frame/rack. Bar shall be mounted at the top most rack mounting unit.
- B. The ground bar located in each rack shall be grounded to the telecomm ground bar (TGB) located in the Telecomm Room with a #6 AWG bonding conductor. Racks shall not be daisy-chained together.

2.9 LABELING

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Coordinate layout and installation of communications equipment with Owner's IT Department and LAN equipment suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with Owner's IT Department and LAN equipment suppliers, local exchange carrier representatives to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.
 - 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
 - 4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
- E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.2 FIRESTOPPING

- A. Comply with requirements in Section 078413 Penetration Firestopping.
- B. Comply with TIA-569-B, Annex A, Firestopping.

3.3 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-B. Comply with requirements as defined in Section 270800 Cable Testing and Administration.
- B. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100

SECTION 271300 - BACKBONE CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Related Documents: Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to the work this section.
- B. Section 270100 Basic Communication Requirements
- C. Section 270528 Pathways for Communication Systems
- D. Section 270800 Cable Testing and Administration
- E. Section 271100 Communications Equipment Room Fittings

1.2 REFERENCES

- A. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both
- B. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean the latest printed edition of each in effect at the date of contract unless the document is shown dated
- C. Conflicts:
 - 1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
 - 2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.
- D. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.0 – Commercial Building Telecommunications Cabling for Customer Premises.
- E. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.1 – Generic Telecommunications Cabling Standard
- F. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.3 – Optical Fiber Cabling Components Standard
- G. Telecommunications Industry Association /Electronic Industries Association ANSI/TIA-568C.3 – Optical Fiber Cabling Components Standard
- H. Telecommunications Industry Association /Electronic Industries Association TIA/EIA) 568B – Commercial Building Telecommunications Wiring Standard
- I. TIA/EIA 569-B – Commercial Building Standard for Telecommunications Pathways and Spaces
- J. ANSI/TIA/EIA 606-B – Administration Standard for Telecommunications Infrastructure of Commercial Buildings
- K. ANSI/TIA/EIA 758-B – Customer-Owned Outside Plant Telecommunications Infrastructure Standard

- L. TIA/EIA TSB-67 – Transmission Performance Specifications for Field Testing of Unshielded Twisted Pair Cabling Systems
- M. TIA/EIA TSB-72 – Centralized Optical Fiber Cabling Guidelines
- N. TIA/EIA PN - 3398 – Cabling practices for Open Offices
- O. TIA/EIA TSB-75 – Additional Horizontal Cabling Practices for Open Offices
- P. International Standards Organization/International Electromechanical Commission (ISO/IEC) DIS 11801
- Q. Underwriters Laboratories (UL) Cable Certification and Follow-up Program
- R. National Electrical Manufacturers Association (NEMA)
- S. American Society for Testing Materials (ASTM)
- T. National Electric Code (NEC) 2014 Current Edition
- U. Institute of Electrical and Electronic Engineers (IEEE)
- V. UL Testing Bulletin
- W. American National Standards Institute (ANSI) X3T9.5 Requirements for UTP at 100 Mbps
- X. Building Industry Consulting Services International (BICSI):
 - 1. Telecommunications Distribution Methods Manual (TDMM) – 13th Edition, Current Edition
 - 2. Customer-Owned Outside Plant Design Reference Manual (OSP) – 5th Edition

1.3 DEFINITIONS

- A. ANSI – American National Standards Institute
- B. AWG – American Wire Gauge
- C. BICSI – Building Industry Consultants International
- D. Mbps – Megabits Per Second
- E. NEC - National Electrical Code
- F. OSP – Outside Plant
- G. PVC – Polyvinyl Chloride
- H. RCDD – Registered Communications Distribution Designer
- I. TR – Telecommunications Equipment Room
- J. UTP – Unshielded Twisted Pair

1.4 SUBMITTALS

- A. Submit all documentation in accordance with the approved project schedule and defined process.
- B. Submit the following for fiber backbone cabling system:
 - 1. Manufacturer's Data for all proposed equipment

- C. Provide shop drawings indicating the intended cable layout and pulling plan prior to beginning cable pulling.
 - 1. Contractor shall provide general procedures for the installation process.
 - 2. Contractor shall identify pulling point locations.
 - 3. Contractor shall identify pulling tensions and bend radii.
- D. Provide calculations and recorded values for actual cable run pulling tensions and recordings of their actual values.
- E. Provide cable inventory data for all fiber and copper cabling and termination equipment. Submit data electronically on CD-ROM in an Owner approved format. Data to be provided includes:
 - 1. Manufacturer's Name
 - 2. Manufacturer's Part Numbers and Comm Code Numbers
- F. Cable Numbers utilizing the Owner cable numbering standard.
- G. Submit Test Plan – Contractor shall develop a fiber optic testing plan for each fiber backbone cable listing preparation requirements, each step required for testing, expected results and acceptable values, applicable standards and specifications cross referenced to specification sections, maximum loss values for all calculations, Owner cable ID, suspension and resumption criteria, and pass/fail criteria. Contractor shall obtain approval of the testing plan from Owner prior to the performance of any testing.

1.5 CONTRACTOR QUALIFICATIONS

- A. All contractors must meet these requirements to be considered qualified for installation:
 - a. The cable and hardware manufacturers of the cabling and hardware to be installed must certify contractor. The contractor must present proof of this certification in advance of bidding the contract.
 - b. Contractor will assign an on staff RCDD to the project. Copy of registration must be submitted at time of bid. The RCDD will visit the job site at least twice a week to review work and schedules.
 - c. The selected low voltage installer shall provide Owner acceptance of the work. Quality and workmanship shall be evaluated by Owner and designated representatives only.

1.6 SUMMARY

- A. Contractor shall furnish and install fiber backbone cabling in order to provide a fully operational, tested, certified and warranted cabling system.
- B. Contractor shall provide all calculations and analysis to support design and engineering decisions as specified in the Submittals section.
- C. Contractor shall comply with all applicable codes, standards, ordinances, regulations, and other legal requirements of public authorities, which bear on performance of Work.
- D. Contractor shall have the chosen manufacturer provide written guidelines for what constitutes warranty liability issues regarding moves, adds, and changes to the cable plant performed by Owner personnel.

1.7 QUALITY ASSURANCE

- A. Installers shall be trained and certified by the manufacturer for the installation of the proposed cabling.
- B. Materials shall be rated for continuous operation under the ambient environmental temperature, humidity, and vibration conditions encountered at the installed location. The materials shall meet the following requirements:
 - 1. Interior Controlled Environment: 64 to 75 degrees F dry bulb and 30 to 55 percent relative humidity, non-condensing
 - 2. Interior Uncontrolled Environment: 0 to 130 degrees F dry bulb and 10 to 95 percent relative humidity, non-condensing.
 - 3. Exterior Environments: Minus 30 degrees to 130 degrees F dry bulb, and 10 to 100 percent relative humidity, condensing.
- C. Standard products: Equipment and materials shall be standard products of a manufacturer regularly engaged in the manufacture of telecommunications cabling products and shall be the manufacturer's latest standard design in satisfactory use for at least one (1) year prior to bid opening.
 - 1. Items of the same classification shall be identical. This requirement includes cable, equipment, modules, assemblies, parts, and components.
- D. Material and equipment required under this contract shall be new, unless otherwise Specified.
- E. Material shall meet requirements of governing codes and regulations.
- F. U.L. Listing: Telecommunication material, equipment and systems, where applicable, shall be UL Listed
- G. Materials shall be delivered in original packages with labels intact and identification clearly marked. Materials damaged prior to final installation acceptance shall be replaced at no cost to Owner.

1.8 DELIVERY, STORAGE AND HANDLING

- A. The contractor is responsible for scheduling all deliveries and shall provide receipt of products and secure proper handling and storage of product prior to installation.
- B. Cable shall be stored according manufacturer's recommendations as a minimum. To a heated (50 degrees F. minimum) location. If necessary, cable shall be stored off site at be stored in a location protected from vandalism and weather. If cable is stored outside, it must be covered with opaque plastic or canvas with provision for ventilation to prevent condensation and for protection from weather. If air temperature at cable storage location will be below 40 degrees F., the cable shall be moved to a heated (50 degrees F. minimum) location. If necessary, cable shall be stored off site at the contractor's expense.

1.9 WARRANTY

- A. The warranty on all materials, services, and adherence of the cabling system to this specification shall be for a period of not less than twenty-five (25) years.
 - 1. If items supplied as part of this project have longer warranties, the Contractor shall supply longer warranty.

- B. The warranty shall certify that the cabling system shall support and conform to ANSI/TIA/EIA specifications covering any current or future application, which supports transmission over a properly constructed cabling system.
- C. The warranty shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).

1.10 SITE OBSERVATION

- A. Visit site prior to preparation of bid and determine conditions that affect execution of work. This includes but is not limited to exact locations of existing equipment, type supports, wire and conduit lengths, ceiling access and sleeves through existing smoked and fire partitions.
- B. Locations and elevation of existing underground facilities such as manholes and poles, sewers, water piping, duct banks, cables, and conduits are as exact as can be determined from available information and their accuracy cannot be guaranteed. Exact location and elevation of these services shall be verified by Contractor prior to excavation or installation of work. Exercise special care when excavating at or near the general location of underground utilities to avoid damage to utility services, as well as to assure safety. Existing services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.
- C. Connections to or relocation of existing utility lines requiring temporary discontinuation of services which are in active use shall be scheduled and coordinated with Utility companies and representatives of Owner. Premium time required for installation of connections and relocations shall be included in bid. Services shall not be left disconnected at end of working day or weekend unless authorized by representatives of Utilities and Owner.
- D. Failure to be acquainted with job site construction conditions under which work is to be performed will not be justified for additional compensation.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Manufacturers for Copper and Fiber Backbone Cabling
 - 1. Corning (Fiber Optic)
 - 2. Superior-Essex (Copper)
- B. Manufacturers for Fiber Enclosure, Splice Trays, Adapter Panels and Fiber Optic Connectors
 - 1. Corning (Fiber Optic)
 - 2. Ortronics (Copper)
- C. Manufacturers for Fiber Splice Cases and Splice Trays
 - 1. Preformed, Coyote Series
 - 2. Engineered Approved Equal
- D. The Contractor shall supply materials as described and shown.
- E. The Contractor shall supply all cabling necessary to interconnect all system equipment including equipment located in the Telecommunications Rooms.

2.2 OPTICAL FIBER GENERAL REQUIREMENTS

- A. Fiber optic cable shall be certified to meet all parts of EIA-455 and comply with the NEC.
 - 1. Cable installed in plenums or air-handling spaces shall meet UL 910 and shall be marked OFNP in accordance with the NEC.
 - 2. Riser cable shall meet UL 1666 and be marked OFNR in accordance with the NEC.
 - 3. Fiber optic patch cords shall be of the manufactured duplex type, and from the same manufacture as the termination hardware and cable to insure compatibility and performance. Field fabricated patch cords shall not be allowed.
 - 4. Proper bend radius shall be maintained throughout the entire run of cabling and at all termination locations.
- B. All fiber optic cable shall utilize the appropriate sheath for the particular application. This shall be in accordance with ANSI/EIA/TIA standards. Any cable placed in space used as an air return or in any way connected with air handling plenums or building ventilation shall be low-smoke, fire retarding cable, and must comply with the National Electrical Code Articles 725, 760, and 800. No cabling shall be placed in plenums without written approval from Owner.
- C. Optical fiber conductors shall follow standard color code schemes. Fiber numbers and binders shall correspond to the color codes as follows:

Fiber/Binder No.	Color	Fiber/Binder No.	Color
1	Blue	7	Red
2	Orange	8	Black
3	Green	9	Yellow
4	Brown	10	Violet
5	Slate	11	Rose
6	White	12	Aqua

- D. Preparation for delivery: The fiber optic cable shall be shipped on reels in lengths as specified with a minimum overage of ten (10) percent.
 - 1. The cable shall be wound on the reel so that unwinding can be done without kinking the cable.
 - 2. Two (2) meters of cable at both ends of the cable shall be accessible for testing.
 - 3. Marking: Each reel shall have a permanent label attached showing length, cable identification number, cable size, cable type, attenuation, bandwidth, and date of manufacture. Labels shall be water resistant and the writing on the labels shall be indelible.
- E. Unless otherwise specified, all fiber optic cables shall be installed in inner duct throughout the entire length of the cable run.
- F. All fiber shall be terminated using factory fan out kits with pre-connectorized terminations. No field installed connectors shall be used.

2.3 SINGLE-MODE FIBER OPTIC CABLE SPECIFICATIONS

- A. Single mode fibers must comply with TIA/EIA 492, ANSI/ICEA S-83-596, and ANSI/ICEA S-83-640. Fiber must comply with TIA/EIA 455 and IEC 793 test methods for required attributes. Fibers shall have dual wavelength capability; transmitting at 1310 and 1550 nm ranges and shall be rated for use as riser cabling. The coating shall be mechanically strippable. The sheath color for all single mode riser and single mode plenum rated cables shall be yellow in color.

- B. The cable shall meet or exceed the following requirements:

Parameter	Requirement
Cable Minimum Bending Radius During Installation: After Installation:	20 times cable diameter 10 times cable diameter
Maximum Fiber Loss Depressed Clad	0.4 dB/km at 1310 NM 0.3 dB/km at 1550 NM
Gigabit Ethernet Distance Guarantee	5000 meters @ 1310 nm and 1550nm
Maximum Dispersion	2.8 ps/nm-km 1285 to 1330 nm
Fiber Macrobend (100 turns @ 75 mm diameter)	~0.05 dB @ 1310 nm ~0.10 dB @ 1550 nm

- C. All Optical Fiber cables shall be shipped with OTDR results for each fiber. OTDR test results shall show attenuation and bandwidth. The results shall be documented in such a manner that the information can be retained for future use.
- D. Interior Building Cables: Building cables shall meet the following requirements:
1. Plenum Rated - Interlocking armored, plenum rated cable consisting of multiple fibers shall have a Plenum PVC outer jacket. Each group of fibers shall have a color-coded Low Smoke PVC buffer. The buffered fibers are organized in subunits of fibers, reinforced with aramid yarn for extra strength and surrounded with a color-coded Low Smoke tube. The cable and each subunit shall be UL listed and meet the NEC requirements for OFNP.
 2. Provide interior building fiber optic cables by Corning, MIC Tight-Buffered, Interlocking Armored, Part # (XX)E88-33131-A3. See drawings for exact fiber strand count (XX).
- E. Outside Plant Cables: Outside plant cables installed in underground ducts or exterior conduits shall meet the following requirements:
1. Outdoor Rated
 2. Shall be dry block.
 3. Strength members shall be FGE/Aramid yarn with extruded PVC sub-cable jacket.
 4. Secondary thermoplastic type buffer over each fiber.
 5. Suitable for underground or above ground conduits.
 6. Shall have individual fiber tube colors per TIA/EIA-606 and overall orange or black jacket.
 7. Provide stiff central member with cables stranded around center.
 8. Suitable for -40deg to +158deg F (operation).
 9. Provide outside plant fiber optic cables by Corning, ALTOS, Loose Tube, Gel-Free, All-Dielectric with FastAccess Technology, Part #(XX)EU4-T4700D20.

2.4 FIBER CASSETTES

- A. Pigtailed splice cassette, single-mode fiber, 1U, LC Quad Connectors. Provide cassette by Corning, Part #CCH-CS(XX)-A9-P00RE. See drawings for exact strand count (XX).

2.5 RACK MOUNT FIBER HOUSING FOR FIBER CASSETTES

- A. Provide suitable rack-mount housing sized to support fiber cassette. Provide housing by Corning, CCH Series.

2.6 SURFACE MOUNT FIBER ENCLOSURE

- A. Provide suitable wall-mount housing to support fiber cassette. Provide housing by Corning, WCH Series.

2.7 SINGLEMODE, LC FIBER CONNECTOR

- A. LC, Single-mode (OS2), ceramic ferrule, field installable, blue housing, blue boot, pre-polished connector. Provide Corning UniCam® High-Performance Connector.

2.8 OPTICAL FIBER CABLE HARDWARE

- A. Fiber splicing and closures: All splices shall be fusion unless specifically approved by the Owner. The fiber splice module shall meet the following specifications:

1. Mechanical

- a. Joins single mode fibers
- b. Establishes a permanent mechanical splice
- c. May be used in outside plant and/or premises applications.
- d. Accept 250 and 900 micron fibers
- e. Re-enterable, re-arrangeable, and reusable
- f. Require no polishing
- g. Require no adhesives
- h. No loose parts
- i. One part index matching gel
- j. Unlimited shelf life

2. Optical

- a. Splice loss < 0.20 dB
- b. Reflection < 50 dB
- c. Stable from -40°F to 185°F (-40°C to 85°C)

2.9 FIBER SPLICE CASE

- A. Coyote Splice Case, 9.5 x 22
 - 1. Preformed Cat. No. 8006877 or Engineered Approved Equal.
- B. Coyote Splice Trays, 36 Fiber
 - 1. Preformed Cat. No. 8001127 or Engineered Approved Equal.
- C. Heat Shrink Tubes
 - 1. Corning Cat. No. 2806031-001
- D. 2-hole Silicone Grommet Kit
 - 1. Preformed Cat. No. 8003701 or Engineered Approved Equal

- E. 4-hole Silicone Grommet Kit
 - 1. Preformed Cat. No. 8003664 or Engineered Approved Equal.

2.10 FIBER PATCH CORDS

- A. Single-mode Fiber Patch Cords
 - 1. Single-mode, duplex fiber patch cable shall be LC-LC, yellow.
 - 2. The single-mode, duplex fiber patch cable shall consist of 9 micron core and a 125 micron cladding. The fiber cladding shall be covered by aramid yarn and OFNR rated, unless otherwise indicated on the drawings.
 - 3. Contractor shall field verify the type and lengths of patch cables, prior to placing order.
 - 4. Contractor shall provide all patch cords required to perform the patching as designated on the contract drawings and specifications. Provide one (1) patch cord for each terminated fiber port at both ends. All slack in the patch cords shall be appropriately dressed using vertical and horizontal patch cord organizers to maintain a neat appearance.

2.11 CATEGORY 3 BACKBONE CABLE

- A. General: Unshielded Twisted-Pair Cat 3 Riser Cable shall distributed in a star configuration from each Main Distributing Frame (MDF) to Intermediate Distributing Frames (IDFs). Size and routing of riser cables shall be as indicated on drawings.
- B. Rating: UL-listed Communications Cable Type CMP for plenum application for indoor applications.
 - 1. Category 3 backbone cable to be installed between the ISB MDF Room and the EAB MDF Room shall be rated for outside plant underground/duct installation.
- C. Cable Construction:
 - 1. 24 AWG solid, copper conductors.
 - 2. PVC insulation with standard telephony color code.
 - 3. Flame retardant PVC jacket.
 - 4. UL type MPR/CMP for riser applications, CMG for general purpose applications.
 - 5. Outside plant cable shall be PE-89 rated.

2.12 CATEGORY 3 BACKBONE TERMINATION EQUIPMENT

- A. Category 3 Punchdown Blocks: Punchdown blocks for copper backbone terminations and horizontal voice (non-VoIP) circuits shall be wall mounted standard Category 3, 110-type connecting blocks providing terminations for 22-26 AWG solid cable. 110 wiring base shall feature sturdy single-piece construction of fire-retardant plastic rate UL 94V-O. Each panel shall be provided with designation strips or labels for labeling each circuit. Blocks shall be sized as per the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION AND VERIFICATION

- A. Verify conduits, raceways, and boxes are properly installed following BICSI recommended practices and ANSI/TIA/EIA 569B standards.

3.2 INSTALLATION

- A. Install work following drawings, manufacturer's instructions, and approved submittal data. The number of cables per run, outlet configuration, and other pertinent data shall be included on the drawings.
- B. All installation shall be done in conformance with ANSI/TIA/EIA and BICSI installation guidelines. The Contractor shall ensure that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines shall require the Contractor to provide, in a timely fashion, the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.
- C. When the outside plant fiber optic cable entering a building exceeds the 50 Foot Rule per the NEC, the contractor shall fusion splice the outdoor rated cable to an indoor plenum rated cable in a fiber splice tray, in a fusion splice case. The splice case shall be sized and installed per the manufacture's and industry specifications.
- D. All fibers shall be run in innerduct and terminated in the communications rooms with LC type connectors in wall, or rack mounted Fiber Optic Distribution Shelves equipped with sufficient panels, couplers and jumper storage shelves to terminate and secure all fibers.
- E. Riser and tie cables shall be extended between communications rooms utilizing the inter-floor conduit sleeves.
- F. All intra-building, optical fiber backbone cables that are going from TR to TR, shall be Single-mode, Interlocking Armored, OFNP unless otherwise noted on the drawings.
- G. All Single-mode fiber shall be fusion spliced to a factory made pigtail with LC type connector.
- H. Cable and protection, installation, and termination, shall be according to the connector manufacturer's recommended practices and shall use the manufacturer's kits, processes, cable and fiber management hardware, fasteners, and other mechanisms necessary for a complete installation.
- I. Cable and fiber terminations shall be labeled.
- J. Cable termination shall incorporate industry standard color coding and positioning within the enclosures
- K. Install the Patch Panels as shown on the drawings. Unless otherwise shown, all enclosures shall be installed tight to each other.
- L. All components of the cabling system shall be installed in a neat and professional manner. Wiring color codes shall be strictly observed and terminations shall be uniform throughout the installation. All cables shall be neatly dressed at the termination points. Final installation shall be subject to Owner approval. The cabling installation shall meet all applicable national and local codes pertaining to low voltage cable system installations.
- M. The Contractor shall adhere to the installation schedule approved by Owner and shall coordinate all construction meetings as agreed with Owner.
- N. The Contractor shall provide service loops (slack) for cables terminating in the main equipment room or the telecommunications rooms. A twenty-five (25) foot service loop shall be provided above the access ceiling or cable trays unless specified otherwise. A twenty-five (25) foot service loop shall be installed in all underground hand holes and manholes.

- O. The installation shall include coordination, testing, and problem resolution with the system vendors.
- P. Upon completion of the installation, the Contractor shall prepare as-built documentation of the entire backbone cable installation as part of the structured cabling system (SCS). This documentation should include:
 - 1. Drawings
 - 2. Documentation
 - 3. This data shall be submitted prior to the use of any system components. System acceptance will not be provided without complete as-built documentation.
- Q. Plastic cable ties shall not be used at any location within this project. All cables shall be bundled using Velcro wraps of the appropriate length. Velcro ties shall be installed in such a manner that cables may be easily removed or added to the cable bundle.

3.3 IDENTIFICATION AND LABELING

- A. All cables, patch panel ports and faceplates shall be labeled with a machine printed (hand written not allowed) label. See Section 270800 Cable Testing and Administration for labeling requirements.

3.4 CONTRACTOR'S FIELD QUALITY CONTROL

- A. All cables shall be tested and reports provided. See Section 270800 Cable Testing and Administration for testing requirements.

END OF SECTION 271300

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SECTION 271500 - HORIZONTAL CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Related Documents: Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to the work this section.
- B. Section 270100 Basic Communications Requirements.
- C. Section 270528 Pathways for Communication Systems
- D. Section 270800 Cable Testing and Administration
- E. Section 271100 Communications Equipment Room Fittings

1.2 REFERENCES

- A. Provide work specified but not shown on Drawings, and work shown on Drawings but not specified, as though expressly required by both.
- B. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean the latest printed edition of each in effect at the date of contract unless the document is shown dated.
- C. Conflicts
 - 1. Between referenced requirements: Comply with the one establishing the more stringent requirements.
 - 2. Between referenced requirements and contract documents: Comply with the one establishing the more stringent requirements.
- D. Telecommunications Industry Association /Electronic Industries Association (TIA/EIA) 568B – Commercial Building Telecommunications Wiring Standards.
- E. TIA/EIA 569A – Commercial Building Standard for Telecommunications Pathways and Spaces.
- F. ANSI/TIA/EIA 606 – Administration Standard for Telecommunications Infrastructure of Commercial Buildings.
- G. ANSI/TIA/EIA 607 – Commercial Building Grounding and Bonding Requirements.
- H. TIA/EIA TSB-67 – Transmission Performance Specifications for Field Testing of Unshielded Twisted Pair Cabling Systems.
- I. TIA/EIA TSB-72 – Centralized Optical Fiber Cabling Guidelines.
- J. TIA/EIA TSB-75 – Additional Horizontal Cabling Practices for Open Offices.

- K. ANSI/TIA/EIA 568-B.2-1 – Additional Transmission Performance Guidelines for 4-Pair 100 Ω Category 6 Cabling.
- L. TIA/EIA PN-3398 – Cabling practices for Open Offices.
- M. International Standards Organization/International Electromechanical Commission (ISO/IEC) DIS 11801.
- N. Underwriters Laboratories (UL) Cable Certification and Follow-up Program.
- O. National Electrical Manufacturers Association (NEMA).
- P. American Society for Testing Materials (ASTM).
- Q. National Electric Code (NEC).
- R. Institute of Electrical and Electronic Engineers (IEEE).
- S. UL Testing Bulletin.
- T. American National Standards Institute (ANSI) X3T9.5 Requirements for UTP at 100 Mbps.

1.3 DEFINITIONS

- A. AWG - American Wire Gauge
- B. Mbps - Megabits Per Second
- C. PDS – Premise Distribution System
- D. PVC - Polyvinyl Chloride

1.4 SUBMITTALS

- A. Submit the following for the horizontal cabling system:
 - 1. Manufacturer's data for all proposed equipment.
- B. List of termination and test equipment to be used for Contractor to perform work.
 - 1. Equipment shall be calibrated with trace ability to National Institute of Standards and Testing (NIST) requirements.
 - 2. Contractor shall include copy of calibration and certification that equipment calibration meets NIST standards and has been calibrated at least once in the previous calendar year.
- C. Shop drawings indicating the intended cable layout and pulling plan prior to beginning cable pulling.
 - 1. Contractor shall provide general procedures for the installation process.

2. Contractor shall identify pulling point locations.
3. Contractor shall identify pulling tensions and bend radii.
- D. Calculations and recorded values for actual cable run pulling tensions and recordings of their actual values.
- E. Cable inventory data for all horizontal cabling and termination equipment. Submit data electronically in an Owner approved format. Data to be provided includes:
 1. Manufacturer's name.
 2. Manufacturer's part numbers and com code numbers.
 3. Cable numbers utilizing the Owner's cable numbering standard.
- F. As-Built (Record Drawings): Furnish as-built CAD drawings of completed work including cable numbers. A full size hard copy and electronic copy on CD-ROM shall be furnished to the Owner's Project Manager.

1.5 QUALITY ASSURANCE

- A. It shall be the responsibility of the Contractor to provide all cable path engineering for the horizontal installation. It shall be the responsibility of the contractor to certify the design of the PDS according to the electrical specifications which are supplied in this document. Additional engineering, diagrams, records, and project management shall be provided by the contractor as stated in other specifications. Diagrams and records should also be coordinated to avoid duplication of efforts and consolidate documentation.
- B. Hardware manufacturer's experience: All components shall be produced by manufacturers who have been regularly engaged in the production of telecommunications cabling components of the types to be installed in this project for a minimum period of five years.

1.6 WARRANTY

- A. A minimum twenty-five (25) year Extended Product Warranty and System Assurance Warranty for this wiring system shall be provided. If items supplied as part of this project have longer warranties, the Contractor shall supply longer warranty.
 1. Extended Product Warranty: The Extended Product Warranty shall ensure against product defects, that all approved cabling components exceed the specifications of TIA/EIA 568B and ISO/IEC IS 11801, exceed the requirements of TIA/EIA TSB 67, TIA/EIA TSB 95, and ISO/IEC IS 11801 for cabling links/channels, that the installation shall exceed the loss and bandwidth requirements of TIA/EIA TSB 67, TIA/EIA TSB 95, and ISO/IEC IS 11801 for fiber links/channels, for a twenty-five (25) year period. The warranty shall apply to all passive PDS components.
 - a) If items supplied as part of this project have longer warranties, contractor shall supply longer warranty.
 2. System Assurance: The System Assurance shall cover the failure of the wiring system to support the application which it was designed to support, as well as additional

application(s) introduced in the future by recognized standards or user forums that use the TIA/EIA 568B or ISO/IEC IS 11801 component and link/channel specifications for cabling, for a twenty-five (25) year period.

3. Extended Product Warranty: The Extended Product Warranty and the System Assurance shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).
4. System Certification: Upon successful completion of the installation and subsequent inspection, the customer shall be provided with a numbered certificate, from the manufacturing company, registering the installation.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers for Cabling

1. Superior Essex – 10Gain XP Category 6A

B. Manufacturers for Termination Hardware

1. Ortronics – Clarity High Density Category 6A

C. The Contractor shall supply materials as described and shown.

1. The Contractor shall supply all cabling necessary to interconnect all system equipment including equipment located in the TeleCommunications Rooms.

2.2 MATERIAL DESIGN AND PERFORMANCE STANDARDS

A. Copper Cable Standards

1. All cable shall utilize the appropriate sheath for the particular application. This shall be in accordance with ANSI/EIA/TIA-568-B.2-10 (or latest approved version) standards. Any cable placed in space used as an air return or in any way connected with air handling plenums or building ventilation shall be low-smoke, fire retarding cable, and must comply with the National Electrical Code Articles 725, 760, and 800. No cabling shall be placed in plenums without written approval from the Owner.
2. Horizontal Cable
 - a) General Performance Specifications: The minimum requirements for all 4 pair, Unshielded Twisted Pair (UTP), Category 6A (or latest approved standard) cables shall conform to TIA/EIA 568B Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section, and be part of the UL LAN Certification and Follow-up Program. Cables shall be marked as UL verified with a minimum of a Category 6A (or latest approved standard) rating. Application standards supported should include, but not limited to, 10Base-T through 10GBaseT Ethernet, Power over Ethernet IEEE 802.3af and IEEE 802.3at, 155Mb/s ATM and 550MHz Broadband Video. In addition, cabling shall be backwards compatible to legacy protocols and applications.

- b) Indoor horizontal cable shall be blue in color, Plenum, Category 6A, Unshielded Twisted Pair (UTP) cable shall be composed of 23 AWG bare solid-copper conductors, insulated (FEP). The insulated conductors are twisted into pairs and sheathed with a low smoke PVC jacket. Cable shall be UL rated CMP. All indoor 4-pair UTP cable shall be plenum rated unless specified otherwise.
- c) Manufacturer Testing: Furnish a copy of the factory certified test report verifying that final production reels are tested to at least 500 MHz and shall meet or exceed 4-connector channel performance requirements specified in ANSI/TIA/EIA-568-B.2-10 (current draft) standard.
- d) Field Testing: All cabling and connectors shall comply with and be tested to ANSI/TIA/EIA-568-A-2 (includes TSB-67) and as specified in Part 3. Cable shall meet or exceed ANSI/TIA/EIA requirements for NEXT, ELFEXT, PSANEXT, PSAACR-F, Attenuation and Return Loss as defined in the respective Standard.

2.3 Components

A. Patch Panels

- 1. 1RU, 19"W, 48 Port Flush Mount Modular Patch Panels.
- 2. Accepts 6-port modules for that snap in and out for easy moves, adds and changes.
- 3. Each jack shall be provided with designation strips or labels on the front and rear for labeling each circuit.
- 4. Provide patch panel by Ortronics, Part# OR-PHD6AU48

B. Connectors/Jacks/Outlets

- 1. All outlets, jacks, and connectors shall exceed all requirements (current draft), Commercial Building Telecommunications Cabling Standard, Addendum 10: Transmission Performance Specifications for 4-Pair Augmented Category 6 Cabling.
- 2. All locations shall utilize "RJ-45 style" 8-position, 8-conductor data jacks in quantities as required and detailed on drawings. All jacks shall be terminated to the 568B wiring scheme.
- 3. Provide Fog White color jacks and faceplates, unless noted otherwise.
- 4. Flush mount faceplates and boxes shall be provided at all locations unless otherwise noted. Exceptions to the specifications which request surface mounting in lieu of flush must be submitted and obtain approval prior to installation.
- 5. Coordination with the modular furniture provider shall be necessary to determine type and design of outlet configurations to be incorporated into the furniture. Provide furniture bezel matching system furniture manufacturer. Jack color shall match furniture color.
- 6. Provide data jacks by Ortronics, Part# OR-HDJ6A.
- 7. Refer to drawings for exact number of ports at each faceplate. Faceplates shall contain label field and match the color of the jacks. Provide matching faceplate by Ortronics.

C. Patch Cables

- 1. Copper Patch Cables
 - a) Provide Category 6A, factory made, Modular Patch Cables for each terminated port on the patch panel, for each connected workstation and for each connected telephone. All patch cables shall conform to the requirements of TIA/EIA 568B Commercial Building Telecommunications Cabling Standard, Horizontal Cabling

Section, and be part of the UL LAN Certification and Follow-up Program. All patch cables shall be factory made and be part of the overall cabling system warranty.

- b) Patch cables for use in Telecomm Rooms shall be seven foot in length and blue in color. Provide patch cord by Ortronics, Part# OR-MC6A07-06.
- c) Patch cables for use at station outlets shall be nine feet long and blue in color. Provide patch cord by Ortronics, Part# OR-MC6A09-06.
- d) All slack in the patch cords shall be appropriately dressed using vertical and horizontal patch cord organizers to maintain a neat appearance.

2.4 COAXIAL CABLE AND CONNECTORS

- A. Single Conductor Coaxial Video Cable: 75 ohm characteristic impedance, Foam FEP core, 18-gauge solid center conductor, copper braid shield, FEP jacket, Type RG 6/U. UL-listed Communications Cable Type CMP for plenum applications.
- B. Single Conductor Coaxial Video Cable: 75 ohm characteristic impedance, Foam FEP core, 14-gauge solid center conductor, copper braid shield, FEP jacket, Type RG 11/U. UL-listed Communications Cable Type CMP for plenum applications.
- C. F-Series crimp-type connector, brass body-copper ferrule, 75ohm impedance, 0-1GHz frequency range, -100 dB min @ 1GHz RF leakage.
- D. Coaxial cable shall meet requirements of ANSI/TIA/EIA-568-B.1 Annex C for the application to be supported.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify conduits, raceways, boxes, cable tray, handholds, and manholes are properly installed following BICSI recommended practices and ANSI/TIA/EIA 569A standards.
- B. Verify backboards are properly installed in all communications rooms.
- C. Patch cords shall be warranted under the same channel and performance warranty as the overall structured cabling system.
- D. Verify that the maximum total length of horizontal cable from the IDF to the individual Jacks shall not exceed 295 feet (90 meters).

3.2 INSTALLATION

- A. Install work following drawings, horizontal cable schedules, manufacturer's instructions, and approved submittal data. The number of cables per run, outlet configuration and other pertinent data shall be included on the drawings.
- B. All installation shall be done in conformance with TIA/EIA 568B, BICSI standards, and manufacturer's installation guidelines. The Contractor shall ensure that the maximum pulling

- tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.
- C. The PDS installation shall meet all applicable national and local codes pertaining to low voltage cable system installations.
 - D. The contractor shall adhere to the installation schedule of the general contractor and should attend all construction meetings scheduled by the general contractor.
 - E. The Contractor shall provide service loops (slack) for all horizontal cables. A 6 foot service loop shall be provided above the access ceiling or in cable trays unless specified otherwise. An additional 6 foot service loop shall also be provided above the finished ceiling (or below the floor) in all work areas. This will allow for future changes or expansion without having to install new cables.
 - F. The installation shall include coordination, testing, and problem resolution with the system vendors.
 - G. The 4-pair UTP cables shall be run using a star topology format from the communications rooms on each floor to every work area information outlet. All cable routes shall be approved by Owner prior to installation of the cabling.
 - H. The Contractor shall observe the bending radius and pulling strength requirements of the 4-pair UTP cable during handling and installation.
 - I. Cables shall be dressed and terminated in accordance with the recommendations made in the TIA/EIA-568-B standard, manufacturer's recommendations and best industry practices.
 - J. Pair untwist at the termination shall not exceed 3.18 mm (0.125 inch).
 - K. Bend radius of the cable in the termination area shall not exceed 4 times the outside diameter of the cable.
 - L. Cables shall be neatly bundled and dressed to their respective panels or blocks. Each panel or block shall be fed by an individual bundle separated and dressed back to the point of cable entrance into the rack or frame.
 - M. The cable jacket shall be maintained as close as possible to the termination point.
 - N. Each cable shall be clearly labeled on the cable jacket behind the patch panel at a location that can be viewed without removing the bundle support ties. Cables labeled within the bundle, where the label is obscured from view shall not be acceptable.
 - O. Each run of cable between the termination block and the information outlet shall be continuous without any joints or splices.
 - P. The Contractor shall conceal horizontal distribution wiring internally within the walls. If obstructions exist, the Contractor shall secure approval by the Owner prior to the use of an alternate method.

- Q. Conduit runs installed by the contractor shall not exceed 100 feet or contain more than two (2) 90 degree bends without utilizing appropriately sized pull boxes.
- R. At any point where station cables and tie cables installed within ceiling spaces must cross electrical circuits, communications cabling shall be routed at right angles to the electrical power circuits.
- S. Each work area outlet shall have a one, two, or four port faceplate over a 4 11/16 x 4 11/16" x 3" deep device box with a single gang device ring, terminating the appropriate amount of Category 6A cables from the telecommunications closet. These cables shall terminate on a Category 6A modular jack, numbered with the labeling scheme identified in the contract drawings.
- T. Plastic cable ties shall not be used at any location within this project. All cables shall be bundled using Velcro wraps of the appropriate length. Velcro ties shall be installed in such a manor that cables may be easily removed or added to the cable bundle.

3.3 CABLE INSTALLATION

A. General

- 1. Any cable placed in space used as an air return or in any way connected with air-handling plenums or building ventilation shall be low-smoke, fire retarding cable, and must comply with the NEC 725, 760, and 800.
- 2. All station cables shall be Category 6A plenum 4-pair unshielded twisted pair (UTP) copper cable. No substitutions will be accepted.
- 3. All cables shall be installed per EIA/TIA 568B building standards to designated stations. All cables shall be terminated on a Category 6A, RJ45, 8 Position, 8 Wire, Universal Modular Jack in a 24 Port Flush Mount Modular Patch Panels within the telecommunication room and on Category 6A, RJ45, 8 Position, 8 Wire, Universal Modular Jack at the station end.
- 4. All cabling will be UL Listed Type CMP if it is placed in air-handling plenums without conduit. The cable sheath will be marked with the UL listing.
- 5. Horizontal UTP and fiber optic cables will not be spliced, nor will these cables contain manufactured splices.
- 6. Contractor shall observe the bending radius and pulling strength requirements of the cabling during handling and installation.
- 7. Contractor shall monitor pull tension continuously during installation and shall not exceed manufacturer's recommended pull tension.
- 8. A cable lubricant specifically manufactured for cable pulling lubrication purposes and compatible with the cable sheathing material may be used on cables pulled in conduits or ducts to meet pull tension requirements.
- 9. Petroleum grease shall not be used as a cable lubricant.
- 10. All vertical cables shall be affixed to a permanent structure or cable tray at each floor in

accordance with industry standards to avoid cable pull back.

11. All conduit and cabinet entrances shall be sealed with an approved, re-enterable sealant material to prevent ingress of water, dust, or other foreign materials.
 12. The Contractor shall conceal all horizontal distribution wiring within conduit in the walls. If it becomes necessary to use an alternative method, the Contractor shall obtain approval from the Owner prior to the use of the alternate method.
 13. Install work following drawings, horizontal cable schedules, manufacturer's instructions, and approved submittal data. The number of cables per run, outlet configuration, and other pertinent data shall be included on the drawings.
 14. The installation shall meet all applicable national and local codes pertaining to low voltage cable system installations.
- B. The installation shall include coordination, testing, and problem resolution with the system vendors. Testing Requirements shall be completed in accordance with Specification 27 0800 Cable Testing and Administration.
- C. Upon completion of the installation, the Contractor shall prepare as-built documentation of the entire horizontal cable installation as part of the Premises Distribution System (PDS). This documentation should include:
1. Drawings
 - a) All drawings shall be provided on CD-ROM in a form compatible with current AutoCAD standards. A complete set of project plans will be provided to the Contractor on CD-ROM. The Contractor shall modify the drawings by placing the cable information on a separate layer. All of the requested drawings shall be placed on these plans so that all cable routes are to scale and provide accurate information for use in the future when changes are made and the exact location of cables are required to avoid service interruptions.
 - b) A complete diagram of all terminations in the MDF and Data Rooms.
 - c) A complete diagram of all copper and fiber cable.
 - d) Floor plans showing exact cable routings.
 - e) A complete diagram of all cable tray, conduits, and conduit sleeves and their associated fill ratios.
 2. Documentation
 - a) All cable inventory data documentation shall be submitted in an Owner approved format, so that data can be incorporated into cable management system databases. This shall include, but is not limited to, cable termination details, cable labeling information, and routing information.
 - b) Complete cross connect documentation is required.
 - c) Complete test results for all installed cables per manufactures testing procedures.

3. This data shall be submitted prior to the use of any system components. System acceptance will not be provided without complete as-built documentation.

3.4 IDENTIFICATION and LABELING

- A. All cables, patch panel ports and faceplates shall be labeled with a machine printed (hand written not allowed) label. See Section 270800 Cable Testing and Administration for labeling requirements.

3.5 CONTRACTOR'S FIELD QUALITY CONTROL

- A. All cables shall be tested and reports provided. See Section 270800 Cable Testing and Administration for testing requirements.

END OF SECTION 271500

SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Protecting existing trees to remain.
 - 2. Removing existing trees.
 - 3. Clearing and grubbing.
 - 4. Stripping and stockpiling topsoil.
 - 5. Removing above- and below-grade site improvements.
 - 6. Disconnecting, capping or sealing, and abandoning site utilities in place and removing site utilities.
 - 7. Temporary erosion and sedimentation control measures.
- B. Related Sections include the following:
 - 1. Division 1 Section "Temporary Facilities and Controls" for temporary utilities, temporary construction and support facilities, temporary security and protection facilities.
 - 2. Division 1 Section "Execution Requirements" for verifying utility locations and for recording field measurements.
 - 3. Division 31 Section "Storm Water Pollution Prevention Plan"
 - 4. Division 31 Section "Earthwork" for soil materials, excavating, backfilling, and site grading.

1.3 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

- A. Record drawings, according to Division 1 Section "Project Record Documents," identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

- A. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Construction Manager.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.

- B. Locate and clearly flag trees and vegetation to remain. **Do not proceed with clearing operations until flagged trees and clearing limits are approved by the Construction Manager.**
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

- A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
 - 1. Do not store construction materials, debris, or excavated material within fenced area.
 - 2. Do not permit vehicles, equipment, or foot traffic within fenced area.
 - 3. Maintain fenced area free of weeds and trash.
- B. Signs, where required on the plans, shall be used tree protection areas. Tree protection signs shall be 11"x15" minimum with minimum font size of 48pt. No sign shall be attached to any tree.
- C. Do not excavate within tree protection zones, unless otherwise indicated.
- D. Root pruning shall occur where excavation or embankment for new construction is required within "tree protection zones" (see definition above). Tearing roots with a backhoe or other mechanized equipment may severely damage the tree and is not an acceptable method. Root pruning shall be performed with a trenching machine or stump removers that cut roots cleanly. Root pruning trenches shall be backfilled immediately to avoid drying out of exposed roots.
- E. Hand cutting of roots with pruning saws is also acceptable. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
 - 1. Cover exposed roots with burlap and water regularly.
 - 2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
 - 3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
 - 4. Backfill with soil as soon as possible.
- F. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Construction Manager.
 - 1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
 - 2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Construction Manager.

3.3 UTILITIES

- A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
 - 1. Arrange with utility companies to shut off indicated utilities.

- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Construction Manager not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Construction Manager's written permission.
- C. Excavate for and remove underground utilities indicated to be removed.
- D. Removal of underground utilities is included in Division 2 Sections covering site utilities.

3.4 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
 - 3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
 - 4. Use only hand methods indicated above for grubbing within tree protection zone.
 - 5. Chip all removed plant material and stockpile in areas approved by Construction Manager. Burning will not be allowed.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to whatever depths are encountered, in sufficient quantities to redistribute topsoil over the site, in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Seed stockpile as specified with temporary cover crop to prevent erosion.
 - 1. Limit height of topsoil stockpiles to 72 inches unless otherwise approved by the Construction Manager.
 - 2. Do not stockpile topsoil within tree protection zones.
 - 3. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.6 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.7 DISPOSAL

- A. Disposal: Remove obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
 - 1. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 31 10 00

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SECTION 31 15 00 – STORM WATER POLLUTION PREVENTION PLAN

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Site Description
 - 2. Storm Water Pollution Control Measures
 - 3. Maintenance Practices
 - 4. Inspection Practices
 - 5. Contractor, Sub-contractor and Utility Company Certifications and Forms
- B. A National Pollution Discharge Elimination System (NPDES), Section 402 Land Disturbance Permit through the Missouri Department of Natural Resources (MDNR) must be held on site prior to proceeding with construction. The construction schedule cannot start without this permit. Contractor claims for Owner delay of project will not be allowed in the event that the permit is not awarded prior to the award of the project. The Owner's representative is responsible for submitting MDNR Forms 'E' and 'G' and the initial Storm Water Pollution Protection Plan (SWPPP) during the plan review process. An award of permit is fully expected prior to the award of project.
- C. MDNR rules, requirements and forms may be obtained from the MDNR at the following address:

Missouri Department of Natural Resources
St. Louis Regional Office
7545 S. Lindbergh, Suite 210
St. Louis, MO 63125
(Phone Number: 314-416-2960)
- D. The contractor assigned the responsibility is responsible for implementing and maintaining all storm water pollution control measures. The assigned responsible contractor shall sign a contractor certification statement called "Contractors Implementing Storm Water Control Measures" located at the end of this specification. The assigned contractor shall maintain a copy of the certification on-file with the Stormwater Pollution Prevention Plan (SWPPP) during construction. The following information shall be included on the certification:
 - 1. Statement: *"I certify under penalty of law that I understand the terms and conditions of the National Pollutant Discharge Elimination System (NPDES) general permit that authorizes storm water discharges associated with construction activity from the construction site identified as part of this certification."*
 - 2. Signature line and title
 - 3. Date

- E. All contractors and sub-contractors who will conduct activities that may impact the effectiveness of storm water pollution control measures shall sign a certification statement that shall be titled "Contractors and Sub-contractors Impacting Storm Water Control Measures". The assigned contractor shall maintain a copy of the certification on-file with the SWPPP during construction. The following information shall be included on the certification:
1. Statement: *"I certify under penalty of law that I will coordinate, either through the assigned contractor, owner or directly with the contractor(s) and or sub-contractor(s) identified in the storm water pollution prevention plan having responsibility for implementing storm water control measures to minimize any impact that actions may have on the effectiveness of these storm water control measures"*
 2. Signature line and title
 3. Date
- F. The Owner's representative will have the authority to observe implementation of the SWPPP and request changes if required. The contractor shall provide owner's representative copies of all records, reports and revisions related to the SWPPP.
- G. Contractor Responsibilities
1. The contractor is responsible for the management of storm water runoff from the site in accordance with the SWPPP. The contractor is responsible for supplying, installing and maintaining all materials required to control pollution from storm water run off.
 2. The contractor will comply with Missouri Department of Natural Resources (MDNR) requirements for NPDES Section 402 Land Disturbance permit and the SWPPP and pay all associated fees and renewal fees that may occur. The Owner is responsible for the initial Form 'E' and Form 'G' application fees. Upon completion of the project the contractor will submit a MDNR Notice of Termination (NOT), Form 'H' or current form to the MDNR.
 3. Execute the certification statement discussed above.
 4. Provide day to day on-site implementation of the SWPPP.
 5. Submit amendments to the SWPPP to the owner's representative if a change occurs in design, construction or maintenance if such event was not addressed in the SWPPP or if the plan proves to be ineffective in eliminating or significantly minimizing pollutants.
 6. Post a notice near the main entrance of the construction site, at the construction trailer or at a prominent location near the construction site for public viewing. The following information should be contained in the notice; Copy of the NPDES permit, name and telephone number of the contractor's site supervisor or project manager, MDNR project coordinator, a brief description of the project and the location of the SWPPP on the job site.
- H. Related Sections include the following:
1. Division 1 Section "Temporary Facilities and Controls" for temporary utilities, temporary construction and support facilities, temporary security and protection facilities.
 2. Division 31 Section "Earthwork" for soil materials, excavating, backfilling, and site grading.
 3. Division 32 Sections "Lawns and Grasses" and "Exterior Plants" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.

1.3 SITE DESCRIPTION

- A. The site is located in the City of Webster Groves, Missouri, 63119, within St. Louis County, at 8274 Big Bend Blvd. The site is served by Garden Road to the south and Big Bend Blvd to the

north. The site is currently a university campus. Major site construction activities include clearing and grubbing, earthwork, construction of bio-retention basin and related storm system, utility infrastructure, school building additions, concrete sidewalks and plazas, finish grading and landscaping. **The site drains to an existing stormwater BMP water quality basin south of the Webster University parking garage. Because of this, there can be no pollutants leaving the site. If pollutants leave the site the contractor is responsible for remediating the damage associated with the event or series of events.**

- B. The intended sequence of construction activities that will disturb soils for major portions of the site are as follows:
1. Clearing
 2. Topsoil stripping and stockpiling
 3. Rough grading operations and spoil mound construction
 4. Excavation for utilities
 5. Excavation for building foundation and service utilities to building
 6. Excavation for sidewalks and plazas
 7. Placing topsoil and finish grading
 8. Landscaping

1.4 SUBMITTALS

- A. Product Data for all manufactured products identified.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials and products use to ensure storm water management will meet or exceed requirements of the SWPPP. Product substitutions are not to be used until approved in writing by the Owner's representative.
1. Silt Fence: Commercially manufactured woven polypropylene fabric that possesses Mullen Burst Strength of over 300 pounds (ASTM D3786), Puncture Strength of 75 pounds (ASTM D4833), Trapezoidal Tear Strength of 50 pounds (ASTM D4533) and Flow Rate/Permitivity of 0.03 gallons per square foot per minute. Wooden stakes supporting fabric shall be 2"x2" or 2"x4" with a minimum length of 3 feet. The fabric shall be stapled to the posts, 6 inches on center maximum staple spacing.
 2. Hay Bales: hay bales shall be constructed of twine or wire bound straw materials. Each bale shall be a minimum of 14 inches wide by 18 inches high by 36 inches long and have a mass of at least 50 pounds. The bale shall be composed entirely of vegetative matter, except the binding material.
 3. Temporary Erosion Control Mat: Commercially manufactured temporary erosion control mat/blanket consisting of a light-weight, non-woven, combination of wood fiber and crimped, interlocking synthetic fibers laminated by an accelerated exterior photodegradable polypropylene netting. The mat shall be un-dyed have a cover factor (C Factor) of 0.012 on a 3:1 slope during a 5 inch rain event for 1 hour test. The mat and fibers shall rate effective for a minimum of 10 months.
 4. Rock Outlet Material: Conforming to St. Louis County Standard Specifications for Highway Construction Section 611.50 Revetment, paragraph 611.52.2. Place rock liner

filter fabric under rock outlet material. Rock liner filter fabric shall consist of a non-woven polypropylene fabric.

5. Rock Check Dam and Construction Entrance/Washdown Area Material: Washed 2" to 3" stone.

PART 3 - EXECUTION

3.1 CONTROLS

A. GENERAL

1. Erosion and sediment shall be retained on-site and out of the pipe storm drainage system to the maximum extent possible.
2. If periodic inspections or other information indicates that a control specified is used incorrectly it shall be replaced or modified to fit the site as approved by the owner's representative.
3. If sediment escapes the erosion control measures the accumulations of sediment shall be removed and erosion control measures repaired and reinforced to eliminate further breaches prior to the next storm event to prevent sediment from being washed into storm sewers.
4. Litter, construction debris, and construction fuels and chemicals exposed to storm water shall be prevented from escaping the site. Such contaminants shall be cleaned up immediately.
5. Off-site vehicle tracking of sediments shall be minimized through the use of stabilized aggregate wash-down areas at construction entrances and exits.

B. STABILIZATION PRACTICES

1. Temporary stabilization practices for this project include temporary seeding as defined in the project details and coverage of finished slopes from 5:1 and greater (steeper) with temporary erosion control mat.
2. Permanent stabilization practices for this project include landscaped and mulched planting beds, seeded and mulched lawn and grass areas and coverage of slopes from 5:1 and greater (steeper) with lawn and grass seed and temporary erosion control mat.
3. Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, or at a maximum of 14 days after the construction activity in that portion of the site has temporarily or permanently ceased except as follows:
 - a. Where construction activity on a portion of the site is ceased, and earthwork activities will resume within 21 days, temporary stabilization measures are not required.
 - b. In areas experiencing droughts where the initiation of stabilization measures by the 14th day after construction activity is ceased is precluded by seasonal arid conditions, stabilization measures shall be initiated as soon as practicable.
4. Stabilization measures shall be initiated as soon as practicable on completed spoil mounds and completed slopes.
5. The following records shall be maintained and attached to the SWPPP: dates when major grading activities occur, dates when construction activities temporarily or permanently cease on a portion of the site, dates when stabilization measures are initiated.
6. All areas beyond the construction limits shall not be disturbed.
7. Access to and from the site shall be via a stabilized (aggregate) construction entrance.

8. The contractor shall phase work within the project site to reduce the total amount of disturbed area.
9. Temporary Seeding: If a portion of the site has not been graded to final elevations and grading operations will be suspended, per the item 3 above, then temporary seed mix shall be installed to stabilize the area.

C. STRUCTURAL PRACTICES

1. Structural practices for this project include construction entrance/washdown areas, perimeter silt fence, detention basin, rock outlet protection, sediment traps, diversion channels, temporary rock check dams, subsurface drains and pipe system and storm drain inlet protection.
 - a. The site entrances and adjacent roadways will be protected with aggregate construction entrances with washdown tank facilities. Stone sediment traps will also be installed at these locations.
 - b. Silt fence shall be installed as indicated on the construction plans prior to commencing construction.
 - c. A detention basin will be formed at the start of mass grading for the project.
 - d. The outlet for the basin will be protected and stabilized with stone rip rap.
 - e. Stone sediment traps will be installed at the detention basin entry points.
 - f. Diversion channels that will guide storm water flow to sediment traps and the detention basin will be cut in during the mass grading.
 - g. Rock check dams will be installed every 100 feet along the diversion channels. Wider swales will be protected with silt fence style check dams.
 - h. Subsurface yard drains and piping will be installed near at the start of the finished grading work.
 - i. Drain inlet protection shall be installed immediately following the installation of drain inlets.

D. MAINTENANCE PRACTICE

1. Construction Entrance/Washdown: The contractor will be responsible to maintain the aggregate entrance and to re-form and replenish the aggregate as it is compressed loses effectiveness to knock off soil and mud. The adjacent sediment traps will need to be cleaned out as silt and sediment reaches half of the sediment trap capacity.
2. Silt Fence: The base of the silt fence barrier shall be maintained in working order as shown on the drawings, any area where the barrier has "blown out" or where water has eroded beneath the barrier shall be repaired to comply with the details. Silt/sediment shall be removed from against the barrier when it reaches half of the height of the barrier. The barriers shall be routinely cleaned such that filtration of runoff occurs.
3. Detention Basin: The stone sediment traps shall be cleaned out when capacity is reduced by half and the silt and sediment re-spread and tilled into gulleys, wash-out areas and over the spoil mounds on-site. Compact, fine-grade, seed and mulch over the placement areas.
4. Rock outlet rip rap should be monitored weekly and after rain events. Replenish and re-form rip rap as required to stabilize the area and prevent erosion.
5. Diversion Channels/swales: monitor swales for erosion of soil, seed and mulch. Re-grade, re-seed with temporary seed as specified on plans and re-mulch disturbed portions of the swales. Repair and replace erosion control matting as required to maintain its effectiveness.
6. Rock Check Dams: monitor all for build-up of sediment. Remove sediment as it reaches 4 inches in height at the dams, re-grade, re-mulch and re-seed with temporary seed as specified on plans.

7. Sub-surface Yard drains and Piping: protect inlets and piping with specified and detailed inlet protection to prevent silt, sediment and construction debris from entering the drainage system. Maintain drains and piping to remain clear and clean at all times. Wash-out of piping and drains is not allowed.
8. Drain Inlet Protection: maintain inlet protection fencing and staking to keep it effective and to avoid any incident of silt or sediment or construction debris from entering the storm drainage system. Remove silt and sediment build-up against the inlet protection fencing as it reaches half the height of the inlet protection fencing.
9. Maintenance of structural practices shall be the contractor's responsibility and shall continue until both permanent erosion controls are in place and permanent soil stabilization (seeded lawns and grasses) is established, as determined by the Owner's representative.
10. Seeded Areas: All seeded areas shall be monitored to ensure that seed germinates and forms a vigorous stand of turf. Any area that has eroded or where seed has been washed away shall be filled in with topsoil, compacted, regraded to finish grades, reseeded and watered in. Sloped areas are to be maintained in the same manner but the areas are to be covered with temporary erosion control mat. Reseed bare areas until a full stand of turf is established.

E. INSPECTION PRACTICES

1. Qualified personnel selected from St. Louis County list of special inspectors shall inspect disturbed areas of the construction site that have not been finally stabilized, areas used for storage of materials that are exposed to precipitation, structural control measures and locations where vehicles enter or exit the site. Such inspections shall be conducted at least once every seven (7) calendar days (or frequency expected by St. Louis County), before anticipated storm events, and within 24 hours of the end of a storm that is one (1) inch or greater.
 - a. Disturbed areas and areas used for storage of materials that are exposed to precipitation shall be inspected for evidence of, or the potential for, pollutants entering the drainage system. Erosion and sediment control measures identified in the plan shall be observed to ensure that they are operating correctly. Where discharge locations or points are accessible, they shall be inspected to ascertain whether erosion control measures are effective in preventing impacts to receiving waters. Locations where vehicles enter or exit the site shall be inspected for evidence of off-site sediment tracking.
 - b. Based on the results of the inspection, the description of potential pollutant sources and pollution prevention measures identified above shall be revised as appropriate as soon as practicable after such inspection. Any changes to this plan resulting from the required inspections shall be implemented within 7 calendar days following the inspection.
 - c. A report summarizing the scope of the inspection, name(s) and qualifications of personnel making the inspection, the date(s) of the inspection, major observations relating to the implementation of this SWPPP (including location(s) of discharges of sediment or other pollutants from the site and of any control device that failed to operate as designed or proved inadequate for a particular location), and actions taken in accordance with the permit shall be made and retained with the SWPPP for at least one (1) year from the date the site is finally stabilized. The report shall be signed and a copy shall be supplied to the Owner.

F. CONTRACTOR, SUB-CONTRACTOR and UTILITY COMPANY CERTIFICATIONS AND FORMS

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. Certification forms for those implementing or conducting activities that may impact the effectiveness of control measures shown on the SWPPP, and who have read all MDNR and SWPPP requirements are provided on the following pages. These signed certifications are to be kept with the SWPPP.
2. A copy of the MDNR Form 'H' Request for Termination of a General Permit can be found on the MDNR website.

END OF SECTION 31 15 00

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CONTRACTORS
IMPLEMENTING STORM WATER CONTROL MEASURES

Statement: ***“I certify under penalty of law that I understand the terms and conditions of the National Pollutant Discharge Elimination System (NPDES) general permit that authorizes storm water discharges associated with construction activity from the construction site identified as part of this certification.”***

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

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CONTRACTORS AND SUBCONTRACTORS
IMPACTING STORM WATER CONTROL MEASURES

Statement: *"I certify under penalty of law that I will coordinate, either through the assigned contractor, owner or directly with the contractor(s) and or sub-contractor(s) identified in the storm water pollution prevention plan having responsibility for implementing storm water control measures to minimize any impact that actions may have on the effectiveness of these storm water control measures"*

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

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UTILITY COMPANY TECHNICIANS
IMPLEMENTING OR IMPACTING STORM WATER CONTROL MEASURES

Statement: *"I certify under penalty of law that I will coordinate, either through the assigned contractor, owner or directly with the contractor(s) and or sub-contractor(s) identified in the storm water pollution prevention plan having responsibility for implementing storm water control measures to minimize any impact that actions may have on the effectiveness of these storm water control measures"*

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

Name(Print)_____ Signature_____ Date_____

Professional Title _____ Company Name_____

Company Address_____

Company Phone_____

SECTION 31 20 00 - EARTHWORK

PART 1 - GENERAL

Note: the geotechnical report is included in these specifications and it shall be used as the basis for construction means and methods.

1.1 DEFINITIONS IN THIS SECTION INCLUDE THE FOLLOWING:

- A. Backfill: Soil materials used to fill an excavation. Pipe backfill is further defined as soil or granular material used to fill a trench excavation above pipe springline.
- B. Base Course: Layer placed between the subbase course and asphalt paving.
- C. Bedding Course: Layer placed over the excavated subgrade in a trench up to springline of pipe.
- D. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations.
 - 1. Additional Excavation: Excavation below subgrade elevations as directed by Construction Manager. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated dimensions without direction by Construction Manager. Unauthorized excavation, as well as remedial work directed by Construction Manager, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subbase Course: Layer placed between the subgrade and base course for asphalt paving, or layer placed between the subgrade and a concrete pavement or walk.
- J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- K. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- L. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Construct Manager and then only after arranging to provide temporary utility services according to requirements indicated.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Soil Materials: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 soil classification groups GW, GP, SW, SP, ML, and CL, or a combination of these group symbols; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. *The contractor shall refer to the geotechnical report or directly with the geotechnical engineer to confirm satisfactory soils prior to construction.*
- C. Backfill and Fill: Satisfactory soil materials.
- D. Subbase Material: Type 1 as per St. Louis County Standard Specifications.
- E. Pipe Bedding: Materials shall be in accordance with requirements of the Metropolitan St. Louis Sewer District Standard Construction Specifications for Sewers and Drainage Facilities, 2009. Refer to MSD standard details as referenced in plans.
- F. Pipe Backfill: Materials shall be in accordance with requirements of the Metropolitan St. Louis Sewer District Standard Construction Specifications for Sewers and Drainage Facilities, 2009. Refer to MSD standard details as referenced in plans
- G. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (38-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
- H. Detectable Warning Tape: Polyethylene film warning tape encasing a metallic core, minimum 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility.

PART 3 - EXECUTION

3.1 PREPARATION:

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Provide erosion and sedimentation control measures in accordance with the Storm Water Pollution Prevention Plan.
- C. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project Site and surrounding area.
- D. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
- E. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions

encountered including rock, soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
- F. Excavate for structures, pavements, and walks to indicated elevations and dimensions. Extend excavations for placing and removing concrete form work, for installing services and other construction, and for inspections. Trim bottoms to required lines and grades to leave solid base to receive other work.
- G. Excavate utility trenches to indicated gradients, lines, depths, and invert elevations of uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit.
 1. Excavate trenches deeper than bottom of pipe elevations, 6 inches (150 mm) deeper in rock, 4 inches (100 mm) deeper elsewhere, to allow for bedding course. Hand excavate for bell of pipe.
- H. Proof roll subgrades, before filling or placing aggregate courses, with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof roll wet or saturated subgrades.
- I. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities.
- J. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by Construction Manager.
 1. Fill unauthorized excavations under other construction or utility pipe as directed by Construct Manager.
- K. Stockpile borrow materials and satisfactory soil materials, without intermixing, in shaped, graded, drained, and covered stockpiles. Stockpile soil materials away from edge of excavations and outside drip line of remaining trees.
- L. Utility Trench Bedding and Backfill: Place, compact, and shape bedding course to provide continuous support for pipes and conduits over rock and other unyielding bearing surfaces and to fill unauthorized excavations.
 1. Place and compact pipe bedding and backfill materials in accordance with requirements of the Metropolitan St. Louis Sewer District Standard Construction Specifications for Sewers and Drainage Facilities, 2009. Refer to plans for standard MSD details. Backfill material shall be compacted crushed limestone and screenings to pavement subbase where under pavement. Compaction of bedding and backfill material shall be at 90 percent of standard Proctor (ASTM D 698) maximum dry density or as directed by the geotechnical engineer.
 2. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.
- M. Fill: Place and compact fill material in layers to required elevations.
- N. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to

within 2 percent of optimum moisture content.

1. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
- O. Compaction: Place backfill and fill materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
- P. Compact soil to not less than the following percentages of maximum dry density as determined by the standard Proctor test, according to ASTM D 698:
1. Under structures, building slabs, steps, and pavements, compact and prepare subgrade and each layer of backfill or fill material at 95 percent of standard Proctor (ASTM D 698) maximum dry density or as directed by the geotechnical engineer.
 2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 95 percent of standard Proctor (ASTM D 698) maximum dry density or as directed by the geotechnical engineer.
 3. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 85 percent of standard Proctor (ASTM D 698) maximum dry density or as directed by the geotechnical engineer.
- Q. Grading: Uniformly grade areas to smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated. Grade lawns, walks, and unpaved subgrades to tolerances of plus or minus 1 inch (25 mm) and pavements and areas within building lines to plus or minus 1/2 inch (13 mm).
- R. Subbase and Base Courses: Under pavements and walks, place subbase course on prepared subgrade. Place base course material over subbase. Compact to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry density as determined by the standard Proctor test, according to ASTM D 698.
- S. Under slabs-on-grade, place drainage course on prepared subgrade. Compact to required cross sections and thickness to not less than 95 percent of maximum dry density as determined by the standard Proctor test, according to ASTM D 698.
- T. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality control testing.
1. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
 2. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.
- U. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled or where they lose compaction.
- V. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- W. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 20 00

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SECTION 312319 - DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes construction dewatering.
- B. Related Sections:
 - 1. Division 01 Section "Construction Progress Documentation Photographic Documentation" for recording preexisting conditions and dewatering system progress.
 - 2. Division 31 Section "Earth Moving" for excavating, backfilling, site grading, and for site utilities.
 - 3. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
 - 4. Division 33 Section "Subdrainage" for permanent foundation wall, underfloor, and footing drainage.

1.3 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
 - 1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
 - 3. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
 - 5. Remove dewatering system when no longer required for construction.

1.4 SUBMITTALS

- A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.

1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
 2. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.
- B. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Missouri professional engineer responsible for their preparation.
- C. Qualification Data: For qualified Installer, land surveyor, and professional engineer.
- D. Field quality-control reports.
- E. Other Informational Submittals:
1. Photographs and Videotape: Show existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by dewatering operations.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.
- C. Preinstallation Conference: Conduct conference at the Project site.
1. Review methods and procedures related to dewatering including, but not limited to, the following:
 - a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
 - b. Geotechnical report.
 - c. Proposed site clearing and excavations.
 - d. Existing utilities and subsurface conditions.
 - e. Coordination for interruption, shutoff, capping, and continuation of utility services.
 - f. Construction schedule. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - g. Testing and monitoring of dewatering system.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
1. Notify Construction Manager no fewer than two days in advance of proposed interruption of utility.

2. Do not proceed with interruption of utility without Construction Manager's written permission.
- B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data.
 1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
 2. The geotechnical report is included elsewhere in the Project Manual.
- C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- C. Provide temporary grading to facilitate dewatering and control of surface water.
- D. Monitor dewatering systems continuously.
- E. Promptly repair damages to adjacent facilities caused by dewatering.

- F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 01 Section "Temporary Facilities and Controls" Division 31 Section "Site Clearing" during dewatering operations.

3.2 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
 - 1. Space well points or wells at intervals required to provide sufficient dewatering.
 - 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
- B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
 - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
 - 1. Maintain piezometric water level in accordance with geotechnical recommendations.
- E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- F. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
 - 1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.
- G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.3 FIELD QUALITY CONTROL

- A. Observation Wells: Provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated; additional observation wells may be required by authorities having jurisdiction.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
 2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
 3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.
- B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

END OF SECTION 312319

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SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes temporary excavation support and protection systems.
- B. Related Sections:
 - 1. Division 01 Section "Construction Progress Documentation Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
 - 2. Division 01 Section "Temporary Facilities and Controls" for temporary utilities and support facilities.
 - 3. Division 31 Section "Dewatering" for dewatering system for excavations.

1.3 PERFORMANCE REQUIREMENTS

- A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
 - 1. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified Missouri professional engineer.
 - 2. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
 - 4. Monitor vibrations, settlements, and movements.

1.4 SUBMITTALS

- A. Shop Drawings: For excavation support and protection system.
- B. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified Missouri professional engineer responsible for their preparation. CONTRACTOR to submit design calculations and drawings for temporary excavation support/sheeting/shoring signed and sealed by a Missouri Professional Engineer for informational purposes only and not for approval of the ENGINEER of record.
- C. Coordinate first paragraph below with qualification requirements in Division 01 Section "Quality Requirements."Qualification Data: For qualified land surveyor and professional engineer.

D. Other Informational Submittals:

1. Photographs or Videotape: Show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems. Submit before Work begins.
2. Record Drawings: Identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions.
 - a. Note locations and capping depth of wells and well points.

1.5 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to excavation support and protection system including, but not limited to, the following:
 - a. Geotechnical report.
 - b. Existing utilities and subsurface conditions.
 - c. Proposed excavations.
 - d. Proposed equipment.
 - e. Monitoring of excavation support and protection system.
 - f. Working area location and stability.
 - g. Coordination with waterproofing.
 - h. Abandonment or removal of excavation support and protection system.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
1. Notify Construction Manager no fewer than two days in advance of proposed interruption of utility.
 2. Do not proceed with interruption of utility without Construction Manager's written permission.
- B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from the data.
1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
 2. The geotechnical report is included elsewhere in the Project Manual.
- C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Construction Manager if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide materials that are either new or in serviceable condition.
- B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
- C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.
 1. Corners: Roll-formed corner shape with continuous interlock.
- D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application.
- E. Shotcrete: Comply with Division 03 Section "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.
- F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
- G. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- H. Tiebacks: Steel bars, ASTM A 722/A 722M.
- I. Tiebacks: Steel strand, ASTM A 416/A 416M.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
 1. Shore, support, and protect utilities encountered.
- B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

- C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.
- D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.
- E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 SOLDIER PILES AND LAGGING

- A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.
- B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.
- C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

- A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

- A. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.
 - 1. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.
 - 2. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.

3.5 BRACING

- A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
 - 1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Construction Manager.
 - 2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.

3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 REMOVAL AND REPAIRS

- A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
 1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.
 2. Fill voids immediately with approved backfill compacted to density specified in Division 31 Section "Earth Moving."
 3. Repair or replace, as approved by Construction Manager, adjacent work damaged or displaced by removing excavation support and protection systems.
- B. If the excavation support and protection system is to be left in place provide the construction manager with the location and top and bottom elevations of all segments.

END OF SECTION 315000

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SECTION 316329 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Dry-installed or slurry displacement-installed drilled piers at Contractor's choice.

1.3 UNIT PRICES

- A. Drilled Piers: Actual net volume of drilled piers in place and approved. Actual length, shaft diameter, and bell diameter if applicable, may vary, to coincide with elevations where satisfactory bearing strata are encountered. These dimensions may also vary with actual bearing value of bearing strata determined by an independent testing and inspecting agency. Adjustments are made on net variation of total quantities, based on design dimensions for shafts and bells.
 - 1. Base bids on indicated number of drilled piers and, for each pier, the design length from top elevation to bottom of shaft, extended through the bell, if applicable, and the diameter of shaft and bell.
 - 2. Unit prices include labor, materials, tools, equipment, and incidentals required for excavation, trimming, shoring, casings, dewatering, reinforcement, concrete fill, and other items for complete drilled-pier installation, including but not limited to the removal of obstructions and additional rock excavation where required.
- B. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed outside dimensions of drilled piers cast against rock. Unit prices for rock excavation include replacement with approved materials.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to drilled piers including, but not limited to, the following:
 - a. Review geotechnical report.
 - b. Discuss existing utilities and subsurface conditions.
 - c. Review coordination with temporary controls and protections.
 - d. Review measurement and payment of unit prices.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete mixture. Submit alternative design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of mixing water to be withheld for later addition at Project site.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. Shop Drawings: For concrete reinforcement, detailing fabricating, bending, supporting, and placing.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer land surveyor and testing agency.
- B. Welding certificates.
- C. Material Certificates: From manufacturer, for the following:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Steel reinforcement and accessories.
- D. Material Test Reports: For each material below, by a qualified testing agency:
 - 1. Aggregates: Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.
- E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Record drawings.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer that has specialized in drilled-pier work.
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077, ASTM D 3740, and ASTM E 329 for testing indicated.
- C. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.9 FIELD CONDITIONS

- A. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
 - 1. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility owner.
- B. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
 - 1. Notify Architect no fewer than two days in advance of proposed interruption of utility.
 - 2. Do not proceed with interruption of utility without Architect's written permission.
- C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses

conducted by geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Conduct exploratory operations as necessary for drilled pier installation.
 2. The geotechnical report is included elsewhere in the Project Manual.
- D. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
1. Record and maintain information pertinent to each drilled pier and indicate on record Drawings. Cooperate with Owner's testing and inspecting agency to provide data for required reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Drilled-Pier Standard: Comply with ACI 336.1 except as modified in this Section.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.
- C. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.
- D. Deformed-Steel Wire: ASTM A 496/A 496M.
- E. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain. Cut bars true to length with ends square and free of burrs.

2.3 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
1. Portland Cement: ASTM C 150/C 150M, Type I/II.
- B. Normal-Weight Aggregate: ASTM C 33/C 33M, graded, 3/4-inch- (19-mm-) nominal maximum coarse-aggregate size. Provide aggregate from a single source.
1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: ASTM C 94/C 94M and potable.
- D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 3. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 4. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

- E. Sand-Cement Grout: Portland cement, ASTM C 150/C 150M, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi (6.9 MPa), of consistency required for application.

2.4 STEEL CASINGS

- A. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
- B. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.
- C. Liners: Comply with ACI 336.1.

2.5 SLURRY

- A. Slurry: Pulverized bentonite pulverized attapulgite or polymers mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

2.6 CONCRETE MIXTURES

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301 (ACI 301M).
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 (ACI 301M) limits as if concrete were exposed to deicing chemicals.
- C. Limit water-soluble, chloride-ion content in hardened concrete to [0.15] [0.30] percent by weight of cement.
- D. Proportion normal-weight concrete mixture as follows:
 - 1. Compressive Strength (28 Days): 5000 psi (34.5 MPa).
 - 2. Maximum Water-Cementitious Materials Ratio: 0.45.
 - 3. Minimum Slump: Capable of maintaining the following slump until completion of placement:
 - a. 4 inches (100 mm) for dry, uncased, or permanent-cased drilling method.
 - b. 6 inches (150 mm) for temporary-casing drilling method.
 - c. 7 inches (175 mm) for slurry displacement method.
 - 4. Air Content: Do not air entrain concrete.

2.7 REINFORCEMENT FABRICATION

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
 - 1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

3.2 EXCAVATION

- A. **Unclassified Excavation:** Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
 - 1. **Obstructions:** Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time are authorized for removal of obstructions.
 - 2. **Obstructions:** Unclassified excavated materials may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. Payment for removing obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.
- B. **Classified Excavation:** Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
 - 1. **Standard excavation** includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
 - 2. **Special excavation** includes excavation that requires special equipment or procedures where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
 - a. Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
 - b. Earth seams, rock fragments, and voids included in rock excavation area are considered rock for full volume of shaft from initial contact with rock.
 - 3. **Obstructions:** Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.
- C. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
- D. Excavate shafts for drilled piers to required elevations. Remove loose material from bottom of excavation.
 - 1. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
 - 2. Remove water from excavated shafts before concreting.
 - 3. Excavate rock sockets of dimensions indicated, minimum of two times the shaft diameter.
 - 4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.

- E. Notify and allow owner's testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.
 - 1. Do not excavate shafts deeper than elevations required unless approved by Architect.
 - 2. Payment for additional authorized excavation is according to Contract provisions for changes in the Work.
- F. End-Bearing Drilled Piers: Drill a 2-inch diameter test hole to a depth below bearing elevation equal to twice the diameter of the bearing area of drilled pier. Make arrangements for the owner's testing and inspection agency to determine whether voids, clay seams, or solution channels exist.
 - 1. Test first three drilled piers and as recommended by the geotechnical inspector, with a minimum of one of every four drilled piers thereafter.
 - 2. Provide the owner's testing and inspection agency with a 2-inch diameter core sample of at least a 6-inch length.
 - 3. Fill augur-probe holes with grout.
- G. Excavate shafts for closely spaced drilled piers, within six pier diameters, and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set for a minimum of 48 hours unless the geotechnical engineer recommends additional wait time based on strata conditions.
- H. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches (1500 mm) above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
 - 1. Excavate and complete concreting of drilled pier on same day, or redrill, clean, and test slurry in excavation before concreting.
- I. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
 - 1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete.
- J. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
 - 1. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

3.3 STEEL REINFORCEMENT INSTALLATION

- A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
- C. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
- D. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.

- E. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.
- F. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

3.4 CONCRETE PLACEMENT

- A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified Special Inspector and testing agency.
- B. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
 - 1. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
 - 2. Vibrate top 60 inches (1500 mm) of concrete.
- C. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no less than 60 inches (1500 mm) into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
- D. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch (1500-mm) head of concrete above bottom of casing.
 - 1. Vibrate top 60 inches (1500 mm) of concrete after withdrawal of temporary casing.
- E. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
- F. Protect concrete work, according to ACI 301 (ACI 301M), from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
 - 1. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - 2. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.
- G. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 (ACI 301M) to maintain delivered temperature of concrete at no more than 90 deg F (32 deg C).
 - 1. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Drilled piers.
 - 2. Excavation.
 - 3. Concrete.

4. Steel reinforcement welding.
 5. Special inspections as required by Section 1704, IBC-2009.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.
1. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers required are to be estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities are determined by the owner's testing and inspecting agency. Final evaluations and approval of data are determined by Architect.
 - a. Downhole Evaluation and Visual Inspection shall be conducted at all drilled piers.
 - b. Bearing Stratum Tests: When requested by the geotechnical engineer, the Testing agency takes undisturbed rock core samples from drilled-pier bottoms; tests each sample for compression, moisture content, and density; and reports results and evaluations.
- D. Concrete Tests and Inspections: ASTM C 172/C 172M except modified for slump to comply with ASTM C 94/C 94M.
1. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
 2. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
 3. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
 4. Compressive-Strength Tests: ASTM C 39/C 39M; one set for each drilled pier but not more than one set for each truck load. Test one specimen at seven days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.
 5. If frequency of testing provides fewer than five strength tests for a given class of concrete, conduct tests from at least five randomly selected batches or from each batch if fewer than five are used.
 6. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 7. Strength of each concrete mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
 8. Report test results in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.
 9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but not be used as sole basis for approval or rejection of concrete.
 10. Additional Tests: Testing and inspecting agency to make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by Architect.

- a. Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.
- 11. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
- 12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- E. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports for each drilled pier as follows:
 - 1. Actual top and bottom elevations.
 - 2. Actual drilled-pier diameter at top, bottom, and bell.
 - 3. Top of rock elevation.
 - 4. Description of soil materials.
 - 5. Description, location, and dimensions of obstructions.
 - 6. Final top centerline location and deviations from requirements.
 - 7. Variation of shaft from plumb.
 - 8. Shaft excavating method.
 - 9. Design and tested bearing capacity of bottom.
 - 10. Depth of rock socket.
 - 11. Levelness of bottom and adequacy of cleanout.
 - 12. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
 - 13. Ground-water conditions and water-infiltration rate, depth, and pumping.
 - 14. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
 - 15. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
 - 16. Date and time of starting and completing excavation.
 - 17. Inspection report.
 - 18. Condition of reinforcing steel and splices.
 - 19. Position of reinforcing steel.
 - 20. Concrete placing method, including elevation of consolidation and delays.
 - 21. Elevation of concrete during removal of casings.
 - 22. Concrete volume.
 - 23. Concrete testing results.
 - 24. Remarks, unusual conditions encountered, and deviations from requirements.
- 3.6 DISPOSAL OF SURPLUS AND WASTE MATERIALS
 - A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 316329

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SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes hot-mix asphalt paving and patching.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
- B. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
- C. Material certificates.

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall be registered with and approved by St. Louis County, Department of Highways and Traffic.
- B. Regulatory Requirements: Comply with St. Louis County Standard Specifications for Highway Construction, dated July 1, 2015 hereafter referred as Standard Pavement Specifications for asphalt paving work.
- C. Asphalt-Paving Publication: Comply with AI MS-22, "Construction of Hot Mix Asphalt Pavements," unless more stringent requirements are indicated.

1.4 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
 - 1. Prime and Tack Coat: Minimum surface temperature of 60 deg F.
 - 2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, 50 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or properly cured, crushed blast-furnace slag.
- B. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, properly cured blast-furnace slag, or combinations thereof.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO MP 1.
- B. Tack Coat: Type MC-30 as per Section 407 of the St. Louis County Standard Specifications.
- C. Prime Coat: Type MC as per Section 408 of the St. Louis County Standard Specifications.

2.3 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with FS TT-P-115, Type I or AASHTO M 248, Type N.
 - 1. Color: White, Yellow.
- B. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than 45 minutes.
 - 1. Color: White, Yellow.
- C. Wheel Stops: Solid, integrally colored, 96 percent recycled HDPE or commingled postconsumer and postindustrial recycled plastic; UV stabilized.
 - 1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes in accordance with St. Louis County Highway Standard Specifications and complying with the following requirements:
 - 1. Base Course: Type X asphaltic concrete as per Section 405.3 of St. Louis County Standard Specifications.
 - 2. Surface Course: Type C asphaltic concrete as per Section 405.3 of St. Louis County Standard Specifications.

PART 3 - EXECUTION

3.1 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Re-compact existing unbound-aggregate base course to form new subgrade.
- B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.10 gal./sq. yd.
- C. Patching: Fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact flush with adjacent surface.

3.2 SURFACE PREPARATION

- A. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
- B. Prime Coat: Apply uniformly to the width of the section to be primed at a rate of 0.2 and 0.5 gallons per square yard.
 - 1. Allow prime coat to cure 12 hours undisturbed before applying hot-mix asphalt paving
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- C. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
 - 1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
- D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.10 gal./sq. yd.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.3 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 - 1. Spread mix at minimum temperature of 250 deg F.
 - 2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.4 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- F. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.5 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Base Course: Plus or minus 1/2 inch.
 - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1/4 inch.
 - 2. Surface Course: 1/8 inch.

3.6 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Construct Manager.
- B. Allow paving to age for 30 days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, crisp, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.
 - 1. Broadcast glass spheres uniformly into wet pavement markings at a rate of 6 lb/gal.

3.7 WHEEL STOPS

- A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and to prepare test reports. All testing requirements shall be per St. Louis County standard specifications.
- B. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.9 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION 321216

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SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes exterior cement concrete pavement for the following:
 - 1. Curbs.
 - 2. Plain concrete sidewalks.
 - 3. Integrally colored concrete sidewalks.

1.2 SUBMITTALS

- A. Product Data and instructions: For each manufactured material and product indicated.
- B. Design Mixes: For each concrete mix indicated.
- C. Material certificates.
- D. Standard color samples for integrally colored concrete and joint sealants.
- E. Certificates indicating compliance with colored concrete specifications.
- F. Test panel (5'x5' min.) for approval to establish standard of quality. Provide at least two weeks prior to placing concrete. The approved test panel may not be used in-place with other colored concrete flatwork. The contractor shall coordinate the location of the test panel with the Owner's representative. Once approved, the test panel shall be protected until the concrete work is complete and approved. The contractor shall provide the number of test panels required to obtain approval at no additional cost to the Owner.

1.3 QUALITY ASSURANCE

- A. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
- B. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Installation by a contractor authorized and with a minimum of five (5) years of documented experience for successful, high quality installations of concrete work specified herein.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Reinforcing Bars: ASTM A 615, Grade 60; deformed.
- C. Dowels: ASTM A 615, smooth steel bars with sleeves.
- D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice."

2.2 CONCRETE MATERIALS

- A. Plain Concrete Pavement
 - 1. Portland Cement: ASTM C 150, Type I or II.
 - 2. Aggregate: ASTM C 33, uniformly graded, from a single source.
 - 3. Water: potable, ASTM C 94.
 - 4. Admixtures: Certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures, as follows:
 - a. Air-Entraining Admixture: ASTM C 260.
 - b. Water-Reducing Admixture: ASTM C 494, Type A.
- B. Integrally Colored Concrete, see Landscape Architect specification if required.
- C. Curing Materials:
 - 1. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
 - 2. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
 - 3. Water: Potable.
 - 4. Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
 - 5. Burlap, plastic sheets or fogging with water shall not be used in conjunction with curing colored concrete.
- D. Related Materials:
 - 1. Expansion Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork with preinstalled bond breaker and removable top strip.
 - 2. Joint Sealant: ASTM C 920, see Section 32 13 73, pavement joint sealants.

2.3 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, with the following properties, St. Louis County Class B-1:
 - 1. Compressive Strength (28 Days): 4000 psi.
 - 2. Maximum Water-Cement Ratio at Point of Placement: 0.45.
 - 3. Slump Limit: 4 inches plus or minus 1 inch.
 - 4. Air Content: 6 percent plus or minus 1.5 percent.

2.4 CONCRETE MIXING AND TESTING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
- B. Testing shall be in accordance with St. Louis County Department of Highways and Traffic construction specification sections 501, 502, and 507.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Proof-roll prepared subbase surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness to match jointing of existing adjacent concrete pavement.
- E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

- A. Moisten subbase to provide a uniform dampened condition at time concrete is placed.
- B. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- D. Screed pavement surfaces with a straightedge and strike off.
- E. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.6 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
 - 1. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture on sidewalks.

3.7 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing methods for colored concrete shall be according to concrete additive manufacturer's instructions.
- F. Curing Methods: Cure concrete by moisture-retaining-cover curing, curing compound or a combination of these methods.

3.8 PAVEMENT TOLERANCES

- A. Comply with tolerances of ACI 117 and as follows:
 - 1. Elevation: 1/4 inch.
 - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3. Surface: Gap below 10-foot-long, unlevelled straightedge not to exceed 1/4 inch.
 - 4. Joint Spacing: 1 inch.
 - 5. Contraction Joint Depth: Plus 1/4 inch, no minus.
 - 6. Joint Width: Plus 1/8 inch, no minus.

3.9 WHEEL STOPS

- A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded in holes drilled or cast into wheel stops at one-quarter to one-third points. Firmly bond each dowel to wheel stop and to pavement. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.10 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove damaged concrete pavement to the nearest joint.
- B. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement.
- C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

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SECTION 321373 - PAVEMENT JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Expansion and contraction joints within cement concrete pavement.
 - 2. Joints between cement concrete and asphalt pavement.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For each type and color of joint sealant required.
- C. Product certificates.
- D. Compatibility and Adhesion Test Reports: From sealant manufacturer.

1.3 QUALITY ASSURANCE

- A. Preconstruction Compatibility and Adhesion Testing: Submit samples of materials that will contact or affect joint sealants to joint-sealant manufacturers for testing according to ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in other Part 2 articles.

2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
 - 1. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

- B. Colors of Exposed Joint Sealants: Shall match surrounding adjacent concrete surfaces. Provide actual cured samples from standard colors for selection by Architect.

2.3 COLD-APPLIED JOINT SEALANTS

- A. Single-Component Jet-Fuel-Resistant Urethane Sealant for Concrete: Single-component, pourable, coal-tar-modified, urethane formulation complying with ASTM C 920 for Type S; Grade P; Class 25; Uses T, M, and, as applicable to joint substrates indicated, O.

1. Products:

- a. Sonneborn, Div. of ChemRex, Inc.; Sonomeric 1.
- b. Shafley Self Leveling Sealant.

2.4 JOINT-SEALANT BACKER MATERIALS

- A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.
- B. Round Backer Rods for Cold- and Hot-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.
- C. Backer Strips for Cold- and Hot-Applied Sealants: ASTM D 5249; Type 2; of thickness and width required to control sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.
- D. Round Backer Rods for Cold-Applied Sealants: ASTM D 5249, Type 3, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
- B. Joint Priming: Prime joint substrates where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience.
- C. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- D. Install backer materials to support sealants during application and at position required to produce optimum sealant movement capability. Do not leave gaps between ends of backer materials. Do not stretch, twist, puncture, or tear backer materials. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.

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Webster University
Cannon Design Project No. 004561.01**

- E. Install sealants at the same time backings are installed to completely fill recesses provided for each joint configuration and to produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
- G. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

END OF SECTION 321373

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SECTION 321400 – UNIT PAVERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Concrete Pavers:
 - 1. Setting: Open joints and pedestals.
 - 2. Setting: Sand.

1.2 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM C 33 - Specification for Concrete Aggregates.
 - 2. ASTM C 150 - Specification for Portland Cement.
 - 3. ASTM C 1260 - Method of Sampling and Testing Brick and Structural Clay Tile.
 - 4. ASTM C 140 - Specification for Concrete.
- B. Tile Council of America (TCA):
 - 1. TCA F102 - Installation Method Cement Mortar Bonded.
 - 2. TCA F101 - Installation Method Cement Mortar Bonded.
- C. American National Standards Institute (ANSI):
 - 1. ANSI A-118.4 - Latex Portland Cement Mortar.
 - 2. ANSI A-118.6 - Grout - Latex.

1.3 SUBMITTALS

- A. Submit under provisions of Section 01300.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Test Reports: Three copies, showing compliance with specified ASTM requirements.
 - 2. Preparation instructions and recommendations.
 - 3. Storage and handling requirements and recommendations.
 - 4. Installation methods.
- C. Shop Drawings:
 - 1. Layout drawings of each paved area showing the pattern of pavers, indicate pavers requiring cutting, indicate setting bed methods in each area, drainage patterns and drains. Include details of setting beds, noting all materials and their thickness, show details at curbs and vertical surfaces.
 - 2. Details of custom (nonstandard) curbs and stair tread/risers, include methods of installation.
- D. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.
- E. Verification Samples: For each finish product specified, three sample pavers of each manufactured, type, size and color selected or specified.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Products shall be produced by a single manufacturer unless otherwise

- specified.
- 2. Manufacturer shall submit evidence of having not less than fifteen years successful production of this product.
- 3. The paver manufacturer shall demonstrate, either by proven field performance or a laboratory freeze-thaw test, that the paving units have adequate durability if they are to be subjected to a freeze-thaw environment.
 - a. Satisfactory field performance is indicated when units similar in composition and made with the same manufacturing process as those to be supplied to the purchaser, do not exhibit objectionable deterioration after at least 3 years.
 - b. The units used as the basis for proven field performance shall have been exposed to the same general type of environment, temperature range and traffic volume as is contemplated for the units supplied to the purchaser.
- B. Installer Qualifications:
 - 1. Subcontractor shall submit evidence of skill and not less than five years specialized experience with this product.
- C. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
 - 1. Finish areas designated by Landscape Architect.
 - 2. Do not proceed with remaining work until workmanship, color, and sheen are approved by Landscape Architect.
 - 3. Refinish mock-up area as required to produce acceptable work.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and handle precast concrete pavers in such a manner as to prevent damage. Units shall be stored above ground on pallets. Pallets shall be clean and non-staining. All damaged or otherwise unsuitable material shall be immediately removed from the job site.
- B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.6 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.
 - 1. Do not work during freezing weather or on wet or frozen sub-base.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer: Wausau Tile Co., which is located at: P. O. Box 1520 9001 Bus Hwy. 51 ; Wausau, WI 54402-1520; Tel: 636-385-0077; Email: bret@wtrep.com; Web: www.wausaupaving.com.
- B. Substitutions: Not permitted.

2.2 PAVERS

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Cannon Design Project No. 004561.01**

- A. Concrete Pavers: Expressions Series Pavers as manufactured by Wausau Tile Co.
 - 1. Thickness: Standard, 2-3/4 inches (70 mm).
 - 2. Nominal Size: As indicated on Drawings.
 - 3. Color: XP-40.
 - 4. Installation Patterns: As indicated on Drawings.
- B. Precast Material Requirements:
 - 1. Precast Cementitious Materials: ASTM C 150 for Portland Cement.
 - 2. Aggregates shall conform to ASTM specifications, except that grading requirements shall not necessarily apply, ASTM C 33 for concrete aggregates, normal weight.
 - 3. Other Constituents: Coloring pigments, integral water repellents, etc., shall be previously established as suitable for use in concrete and either shall conform to ASTM Standards where applicable, or shall be shown by test or experience not to be detrimental to the durability of the concrete.
- C. Paver Performance Requirements:
 - 1. Compressive Strength: At the time of delivery to the work site, the average compressive strength shall not be less than 8,000 psi with no individual unit less than 7,000 psi (48,000 kPa) per ASTM C 140.
 - 2. Absorption: The average shall not be greater than 6 percent per ASTM C140.
 - 3. Flexural Strength: Not less than 800 psi (5500 kPa) per ASTM 293.
 - 4. Load carrying capacity: Paver units shall have a tested center load capacity of 1,850 lb (840 kg). WT CL96
 - 5. Freeze/thaw: Durability of the paver shall meet the freeze/thaw tests in accordance with Section 8 of ASTM C1260. Specimens, when tested, shall have no breakage and not greater than 1 percent loss in dry weight of any individual unit when subject to 50 cycles of freeze/ thaw.
 - 6. Sizing: Permissible variations in dimensions shall not differ by more than 1/16 inch (1.6 mm) from width, height, length or thickness. Standard units are manufactured with a 3/16 inch (4.8 mm) bevel on all four sides of finished surface. Unit shall conform to a true plane and not differ by more than 1/16 inch (1.6 mm) in either concave and/or convex warpage.

2.3 INSTALLATION MATERIALS

- A. System: Open Joint Pedestal Set.
 - 1. Work shall include rigid board insulation, concrete pavers and accessory materials required for complete and proper installation of the pavers system.
 - 2. Tabs and Shim Plates:
 - a. The SBR rubber Terra-Tab as manufactured by Wausau Tile Co. Units shall provide spacing tabs 3/16 inch (4.8 mm) or 1/8 inch (3 mm) allowing for drainage and air circulation. Tabs to have a shore hardness of 70, allowing for resiliency without sound transmission. Tab sizes to correspond with various sizes of pavers.
 - b. Shim Plates (shims) are 1/8 (3 mm) and 1/4 inch (6 mm) thick and of various sizes to correspond with various size tabs. Shim plates shall be of the same material as the tab.
 - 3. Pedestal Systems:
 - a. Adjustable Pedestals: Terra-Adjust Adjustable Pedestals as manufactured by Wausau Tile Co. To accommodate various pitches/slopes of project areas. Unit shall have an outside base diameter of 6-1/8 inches (156 mm) giving a contact surface area of 29-1/2 sq. inches (19,000 sq. mm). Unit telescopes from a minimum 2

- inches (51 mm) to a maximum 5-1/2 inches (140 mm) and can tilt to a level plane. Extenders and reducers to be used in areas requiring over 5-1/2 inches (140 mm) or under 2 inches (51 mm) in height. Units to be high impact styrene. Tabs are used on top of this unit.
- b. Stand Pedestals: Terra-Stand Pedestals as manufactured by Wausau Tile Co. To accommodate various pitches and height changes of the project area. Unit has outside dimension of 7 inches (178 mm). Unit telescopes from a minimum of 2 inches (51 mm) to a maximum of 21 inches (533 mm) and can tilt to a level plane. Units to be high impact copolymer Polypropylene. Tabs are used on top of this unit.
- 4. Reducer Pedestal System:
 - a. Extenders/Reducers: Extender gives an additional 4 inches (102 mm) adjustment to a maximum height of 10 inches (254 mm). Reducer is made to accommodate height adjustment between 1/2 inch (13 mm) and 2 inches (51 mm). Units to be high-impact styrene. Tab and shim plates with spacer unit are used on top of this unit.
 - b. Waffle Reducer: The waffle Reducer is made of high impact copolymer polypropylene. Waffle Reducer is made to accommodate height adjustments 1/2 inch (13 mm) to 2 inches (51 mm). An outside base diameter of 6 inches (152 mm) provides surface contract of 33 square inches (21,290 sq. mm). The unit consists of one base with 3 pieces of 3/8 inch (9.5 mm) waffle rings and 1 piece of 3/4 inch (19 mm) waffle ring.
 - 5. Installation Handles:
 - a. Paver Blok Handles: Units to handle paver sizes 12 inches to 24 inches (305 mm to 610 mm) nominal, allowing installing contractor to set units into proper location with 3/16 inch (4.8 mm) or 1/8 inch (3 mm) joint between units. Also allows for removal and reinstallation units without causing any damage to units or adjacent units, thus allowing inspection of utilities or drains at any time.
 - b. Big Blok Handle: Unit to handle paver sizes 24 inches to 36 inches (610 mm to 914 mm) nominal, allowing installing contractor to set units into proper location with 3/16 inch (4.8 mm) or 1/8 inch (3 mm) joint between units. Also allows for removal and reinstallation without causing any damage to units or adjacent units, thus allowing inspection of utilities or drains at any time.
 - 6. Terra System One Mix:
 - a. Pre-mixed blended concrete dry mix to be used with the Terra-adjust System to have a 5,500 psi (38,000 kPa) at 28 days compressive strength.
 - b. Material shall comply with requirements of ASTM C387.
 - 7. Other Accessory Materials:
 - a. Shall be either provided by the manufacturer of the precast concrete pavers and precast units, or shall be specifically recommended by them.
- B. System: Sand-Set Installation.
- 1. Sand Setting Bed Material: Sand shall common sand generally referred to as concrete sand and shall free of organic materials and any other contaminates that could potentially stain or otherwise damage the unit pavers.
 - 2. Joint Filler Materials: Sand conforming with ASTM C 144 with 100 percent passing a No. 16 sieve.
 - 3. Landscape Filter Fabric: Woven or non-woven non-biodegradable filter between the compacted base and the sand leveling bed.

4. Preformed Asphalt Joint Filler where indicated on drawings: ASTM D 994, 1/2 inch (13 mm) thick, for expansion joints which are not sealed, one of the following:
 - a. Code 1301, W.R. Grace and Co.
 - b. Asphalt Expansion Joint, W. R. Meadows, Inc.
 - c. Elastite Asphalt Expansion Joint, The Celotex Corporation.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Landscape Architect of unsatisfactory preparation before proceeding.
- C. Concrete shall not exceed 1/8 inch in 10 feet (3 mm in 3 m) from required plane. Concrete to be steel troweled with fine broom finish. No curing or sealing compound used.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Placement Tolerance:
 1. Maximum of 1/16 inch (1.6 mm) height variation between adjacent pavers.
 2. Individual pavers shall not vary more than 1/16 inch (1.6 mm) from level across width of the paver.
 3. Paved areas shall not vary more than 1/4 inch (6 mm) from level in a distance of 10 feet (3 m) measured at any location and in any direction.
 4. Joints between pavers to be 3/16 inch (4.8 mm) or 1/8 inch (3 mm).
- C. Sand Setting Bed Installation:
 1. Place solid steel 3/4 or 1 inch (19 mm or 25 mm) thick control bars directly on the base. Install shims under bars for minor adjustment of depth and finish paver elevations and slopes. Space bars approximately 11 feet (3.4 m) apart and parallel to each other to serve as guides for strike-off boards.
 2. Place sand setting bed between control bars on the binder course to not less than thickness of the designated control bars. Spread material and strike off by pulling the material with a 12 feet long by 2 inches by 6 inches (3.7 m by 51 mm by 152 mm) wood board several times to produce a smooth firm and even setting bed. Add fresh material in low areas after each pass of the strike off board. After each panel is complete remove and advance the first control bar to the next panel position in readiness for placing and striking adjacent panels. Fill in depressions left by the control bar and any shims.
- D. Pedestal and Open Joint Installation:
 1. Inspection of deck and fixed elevation locations. All height or location problems to be corrected before installation.

2. Compare layout of deck to shop drawings or Landscape Architectural drawings. All variances of field conditions to drawings to be reviewed and corrected prior to starting installation.
3. Tabs and shim plates are placed, maximum of 2 shims per location, at intersection of grid line if finished surface is to follow slope of substrates. Paver size centerlines shall be adhered to.
4. Level surface installation using adjustable or stand screw-top pedestal to follow manufacturer's installation procedures. No variances to system allowed.
5. Minor height and pitch adjustments are handled with 1/8 inch (3 mm) rubber shim plates.
6. Extender unit is inserted into extended pedestal to provide heights from 5-1/2 inches to 10 inches (140 mm to 254 mm).
7. Reducer unit is used for height adjustments of between 1/2 inch and 2 inches (13 mm and 51 mm) in 3/8 inch (9.5 mm) increments.

3.4 PROTECTION

- A. Protect installed products until completion of project.
- B. Remove and replace pavers which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment to eliminate evidence of replacement.
- C. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 321443 - POROUS UNIT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Concrete grid pavers with aggregate fill.
 - 2. Solid concrete pavers with openings between pavers filled with aggregate.
 - 3. Aggregate setting bed for pavers.
 - 4. Edge restraints.
 - 5. Precast concrete curbs.
 - 6. Granite curbs.
- B. Related Requirements:
 - 1. Section 312000 "Earth Moving" for excavation and compacted subgrade.
 - 2. Section 321313 "Concrete Paving" for cast-in-place concrete curbs that serve as edge restraints for porous paving.
 - 3. Section 321400 "Unit Paving" for nonporous unit paving.
 - 4. Section 329300 "Plants" for planting ground cover in porous paving.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For materials other than aggregates.
- B. Product Data: For the following:
 - 1. Pavers.
 - 2. Edge restraints.
 - 3. Geotextiles.
- C. Sieve Analyses: For aggregate materials, according to ASTM C 136.
- D. Samples:
 - 1. Full-size units of each type of unit paver indicated.
 - 2. Exposed edge restraints.

3. Aggregate fill.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.
- B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
 1. For grid paving units, include durability test data based on testing according to proven field performance requirements of ASTM C 1319 performed on units subjected to three years' exposure to same general type of environment, temperature range, and traffic volume as Project.
 2. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C 67.

1.6 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of paver from single source that has resources to provide materials and products of consistent quality in appearance and physical properties.
- B. Acceptable Manufacturer: Hanover Architectural Products. 5000 Hanover Road, Hanover PA, 17331. Email: info@hanoverpavers.com. Phone: (717) 637-0500. <http://www.hanoverpavers.com>
- C. Substitutions: Not permitted.

2.2 PAVERS

- A. Concrete Pavers: Permeable series by Hanover Architectural Products.
 1. Thickness: 3"

2. Nominal Size: 12" X 18"
3. Color: Matrix #2922
4. Installation Patterns: As indicated on Drawings.

2.3 ACCESSORIES

- A. Aluminum Edge Restraints: L-shaped, 3/16 inch thick by 2-1/4 inches high extruded-aluminum edging, with loops pressed from face to receive stakes at 12 inches o.c., and with aluminum stakes 12 inches long for each loop.

2.4 AGGREGATE SETTING-BED MATERIALS

- A. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 57.
- B. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
- C. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
- D. Filter Fabric: MSD type 4.

2.5 FILL MATERIALS

- A. Soil Fill for Porous Paving: Planting soil, Cornell University Structural Soil. See drawings for extents.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared subgrade according to requirements in Section 312000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with porous paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for porous paving.

3.2 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
- D. Tolerances:

1. Variation in Plane between Adjacent Units (Lipping): Do not exceed 1/16-inch unit-to-unit offset from flush.
 2. Variation from Level or Indicated Slope: Do not exceed 1/8 inch in 24 inches and 1/4 inch in 10 feet or a maximum of 1/2 inch .
- E. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after porous paver installation.
 2. For metal edge restraints with top edge exposed, drive stakes at least 1 inch below top edge.
- F. Provide curbs as indicated. Install curbs before placing unit pavers.

3.3 SETTING-BED INSTALLATION

- A. Compact subgrade uniformly to at least 95 percent of ASTM D 698 laboratory density.
- B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Place Filter Fabric over prepared subgrade, overlapping ends and edges at least 12 inches .
- D. Place aggregate subbase, compact by tamping with plate vibrator, and screed to depth indicated.
- E. Place aggregate base, compact to 95 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
- F. Place leveling course, and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

3.4 PAVER INSTALLATION

- A. Set unit pavers on leveling course, being careful not to disturb leveling base. If pavers have lugs or spacer bars to control spacing, place pavers hand tight against lugs or spacer bars. Use string lines to keep straight lines.
- B. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches of uncompacted pavers adjacent to temporary edges.
 2. Before ending each day's work, compact installed concrete pavers except for 36-inch width of uncompacted pavers adjacent to temporary edges (laying faces).
 3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches of laying face.

4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
- C. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.
1. Before ending each day's work, place aggregate fill in installed porous paving except for 42-inch width of unfilled paving adjacent to temporary edges (laying faces).
 2. As work progresses to perimeter of installation, place aggregate fill in installed paving that is adjacent to permanent edges unless it is within 42 inches of laying face.
 3. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
- D. As work progresses, remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION 321443

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SECTION 328400 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Related Sections:
 - 1. Division 01 "Summary of Work" for limits placed on Contractor's use of the site.
 - 2. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees that interfere with or are affected by execution of work.
 - 3. Section 311000 "Site Clearing" for removal limits of trees, shrubs, and other plantings affected by New Construction.
 - 4. Section 312300 "Excavation and Fill" for excavation, filling and rough grading, and for subsurface aggregate drainage and drainage backfill materials.
 - 5. Section 322200 "Earthmoving" for building and utility trench excavation, backfilling, compacting and grading requirements, and soil materials.
 - 6. Section 329200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
 - 7. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
 - 8. Section 334600 "Subdrainage" for below-grade drainage of landscaped areas.

1.3 DESCRIPTION OF WORK

- A. The work required is indicated on the drawings and includes, but is not limited to, the design, installation, and maintenance of lawn and planting area irrigation systems, backflow prevention devices, protective housings, automatic controller(s), rain sensors, remote control valves, quick coupler valves, and water and electric services.
- B. Irrigation system shall be designed as a new system. Connections and zones should be logical in design and appropriate for existing equipment and water service.
 - 1. Contractor shall verify extent of any exiting system prior to start of design for this scope of work.
 - 2. Contractor shall familiarize himself with all existing and proposed conditions including grade differences, location of walls, site features, utilities, and all other site improvements.
- C. Coordinate with Landscape Contractor the placement, type, and water requirements for all plant material.

- D. Areas of underground irrigation system are to include all lawn areas, planting beds, and other disturbed areas as defined in the bid documents. The contractor shall provide the design of the specific system. The system shall be in accordance with the following design criteria:
1. Design of irrigation system shall conform to current industry standards and comply with local and state governing codes.
 2. Location of all major components (i.e.: controller, backflow preventer, meter, etc.) shall be coordinated with the owner.
 3. All irrigation system(s) shall be designed to minimize vandalism, including lockable protective housings for all equipment installed in location accessible to the public.
 4. For each point of connection, submit pressure calculations for the system(s) with the highest psi requirement to operate properly allowing for friction losses within the system. Water velocity within the system shall not exceed 5 fps. In the event pressure differences are not reported prior to start of construction, the irrigation contractor shall assume full responsibility for any revisions necessary.
 5. Irrigation system(s) shall have the design capability of delivering 1" of water in a 5 day period.
 6. The minimum coverage requirements are 100% head-to-head coverage in lawn area, 90% in all bed areas.
 7. Irrigation water shall be applied at a rate which does not exceed the infiltration rate of the soil and system(s) shall be programmed to prevent ponding and runoff.
 8. Provide separate control valves for sprinkler line operating at the top, toe, and intermediate areas of slopes.
 9. Irrigation system shall be designed to meet the peak moisture demand of all plant materials used within the design area. Separate zones and irrigation methods shall be used for trees, ground cover, planting areas, and turf and sunny vs. shaded areas where applicable.
 10. Irrigation system shall be designed and operated to minimize fogging, overspray, and discharge onto areas not under control of the user including streets and sidewalks.
 11. Sprinkler heads used in turf areas shall be equipped with protective covers.
 12. All sprinkler heads shall be "pop-up" type unless otherwise noted.
 13. Irrigation system shall be designed for positive winterization. Provide blowouts where positive drainage is not met.
 14. Design system(s) to lowest available pressure per local water company's records.
 15. Gate Valves shall be provided to allow shutting down various sections of the system independent of the entire system. Each section shall not exceed four (4) remote control valves. Valves shall be installed per manufacturer's recommendations and local codes and ordinances.
 16. All backflow prevention devices must comply with requirements set forth by the local health department and city water department. Prevent any back-siphoning after sectional valves are closed. Backflow prevention devices are not permitted on irrigation systems using reclaimed water.
 17. Locate remote control valves in shrub areas when possible. All valves to be in green Ametek boxes, or approved equal. Remote control valves shall be located outside of storm water detention areas or designated athletic play areas (where applicable).
 18. Anti-drain valves in line and/or under sprinkler heads are to be properly installed on sloped irrigation systems to minimize to of slope sprinkler drainage.
 19. Rain sensor shall be connected to the irrigation controller, out of public view.
 20. Provide construction details for components.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Indicate on product data sheets (circle, highlight) which products will be used during the construction of the project. Ensure sheets are scanned and submitted right side up.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Shop Drawings: Submit shop drawings in AutoCAD format, or approved equivalent for underground irrigation system including:
 - 1. Plan layout and details illustrating:
 - a. Point of connection.
 - b. Location and type of heads.
 - c. Valves.
 - d. Piping circuits.
 - e. Controls.
 - f. Electrical information.
 - g. Accessories.
 - 2. Drawings shall be sealed and signed by a Certified Irrigation Designer.
 - 3. Drawings shall not exceed 1" = 20'.
 - 4. Color-coded zone diagram to differentiate zones.
- D. Substitutions: Submit all desired substitutions for review by the Owner prior to, or simultaneous to, the submittal of the Contractor's bid.
- E. Record Drawings (commonly called 'As Built Drawings'):
 - 1. Record accurately on one set of contract drawings all changes in the work constituting departures from the original shop drawings. Maintain Record Drawings on site at all times.
 - 2. The changes and dimensions shall be recorded in a legible and workmanlike manner to the satisfaction of the Landscape Architect. Prior to final inspection of the work, submit Record Drawings.
 - 3. Dimensions shall be from two permanent points of reference (buildings, monuments, sidewalks, curbs, pavements, etc.). Data to be shown on Record Drawings shall be recorded day-to-day as the project is being installed. All lettering on drawings shall be 1/10-inch in size, minimum.
 - 4. Show locations and depths of the following items:
 - a. Point of connection.
 - b. Routing of sprinkler pressure lines.
 - c. Gate valves.
 - d. Sprinkler control valves.
 - e. Quick coupling valves.
 - f. Routing of control wires.
 - g. All related equipment (backflow prevention device(s), controller, rain sensor, etc.).
 - 5. The following charts, manuals, and equipment shall be turned over to the Owner or Landscape Architect no later than 10 days prior to the final inspection at the end of the maintenance period.

- a. Record Drawings must be approved by the Landscape Architect before controller schedules and charts are prepared.
 - b. Submit a schedule indicating the controller, the station number, the valves controlled by the station, and the length of time each valve is to remain open to produce 1" minimum of precipitation per week.
 - c. Provide one (1) controller chart of maximum size controller door will allow for each automatic controller. The chart shall show the area covered by the controller.
 - 1) The chart is to be a reduced copy of the actual Record Drawing. In the event the controller sequence is not legible when the drawings are reduced, it shall be enlarged to a readable size.
 - 2) Chart shall be on a black line print with different colors used to show the area of coverage for each station.
 - 3) When completed and approved, the chart shall be hermetically sealed between pieces of plastic, each piece being a minimum of 20 mil thickness.
 - 4) Controller charts shall be completed and installed prior to Substantial Completion.
6. All field changes shall be updated in the shop drawings using the same software that created the shop drawings. Record Drawings shall be submitted as a PDF, or approved equal.
- F. Qualification Data: For qualified installer.
- G. Operation and Maintenance Manuals: One digital file as PDF, or approved equal, of operation and maintenance manual shall be delivered to the Landscape Architect ten (10) calendar days prior to final acceptance inspection. The manual shall describe the material installed. The manual shall include the following information:
1. Index sheet stating the Project Name, Contractor's Company Name, contact person, Company address, telephone number, expiration date of the guarantee period, list of equipment including names and addresses of local manufacturer representatives.
 2. Complete operating and maintenance instructions for all equipment.
 3. Spare parts lists and related product and manufacturer information for all equipment.
- H. Closeout Submittals shall be completed and submitted prior to the issuance of the Final Payment.
- I. Inspection Records: Any inspection that does not pass shall be corrected at the Contractor's expense.
- J. Equipment: Supply as part of this contract the following items:
1. Two (2) keys for each automatic controller.
 2. Two (2) valve box cover keys or wrenches.
 3. Two (2) 5' tee wrench for operating gate valves 2-1/2 inches or larger.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide underground irrigation system as a complete unit produced by the approved manufacturers including heads, valves, controls, and accessories.

- B. **Installer Qualifications:** An employer of workers that include a certified irrigation designer qualified by The Irrigation Association and a company having not less than 5 years of experience in the installation of automated irrigation systems using experienced installers who have worked on projects similar in size and scope of the proposed project. Subcontract irrigation work to an experienced, single firm specializing in irrigation design, installation, and operations. Irrigation installer to have state certification. Irrigation Contractor to provide 3 references of work that is of similar size, scope, and expected craftsmanship as those shown in the Contract Documents. References shall include project name and address, owner's or general contractor's name, and current contact information. Irrigation Contractor shall be approved by Owner.
- C. **Electrical Components, Devices, and Accessories:** Installation shall be by a licensed electrical contractor as required by local and state regulatory requirements to provide a fully operative irrigation system. Electrical contractor shall provide Owner's Representative documentation of inspection and approval of work by all governing regulatory agencies.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.
- C. All other components.

1.7 PROJECT CONDITIONS

- A. **Interruption of Existing Water Service:** Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without Owner's written permission.

1.8 WARRANTY

- A. **Description:** For a period of one (1) year after date of Substantial Completion of work performed under this Contract, Contractor shall promptly furnish and install, without cost to Owner, parts which prove to be defective in material or workmanship.
- B. Shut down and start-up service

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturers for irrigation system equipment are:

1. Rain Bird Corporation.
2. The Toro Company (Toro and Irritrol brands).
3. Hunter Industries.
4. Netafim USA (Drip Irrigation products).
5. Watertronics (water harvesting).
6. Approved Equal.

2.2 MATERIALS AND EQUIPMENT

A. General requirements:

1. New materials and equipment.
2. PVC pipe, drip tubing, fittings, isolation valves, control valves, drip zone valve kits, valve boxes, controller(s), decoder(s), flow sensors, rain gauge, and rain sensor shall all be compatible.

2.3 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. PVC Pipe: Provide clean, dry, and covered location for storage of all pipe during installation.

2.4 PIPING JOINING MATERIALS

- A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656. Solvent shall contain pigment.
- B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.5 AUTOMATIC CONTROL VALVES

- A. Manufacturers: Automatic control valves to be manufactured by the same manufacturer as the control system (controller) on the project.

2.6 AUTOMATIC DRAIN VALVES

- A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig .

2.7 MISCELLANEOUS SPECIALTIES

- A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
- B. Pressure Gages: ASME B40.1. Include 4-1/2-inch-diameter dial, dial range of two times system operating pressure, and bottom outlet.

- C. Quick Coupling Swing Joints: Schedule 40 PVC tee and 1-inch swing joint with three 90 degree elbows.
- D. Rain Gauge: Provide and install tipping rain gauge, compatible with control system.
- E. Flow Sensor: Provide and install flow sensor compatible with control package being installed.
 - 1. Flow sensor shall be installed according to manufacturer's recommendations, positioned after/downstream from master valve. Install with manufacturer's recommended distances before and/or after other devices (master valve and mainline tees/fittings).
- F. Rain Sensor: Provide and install rain sensor compatible with control system.

2.8 SPRINKLERS

- A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.
- B. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Description:
 - a. Body Material: ABS.
 - b. Nozzle: ABS.
 - c. Retraction Spring: Stainless steel.
 - d. Internal Parts: Corrosion resistant.
 - 3. Capacities and Characteristics:
 - a. Flow: Per system requirements.
 - b. Pop-up Height: 6 inches to 18 inches aboveground to nozzle.
 - c. Arc: as required to provide even coverage without overspary.
 - d. Radius: Provide for head-to-head coverage.
 - e. Inlet: NPS 1/2 or NPS 3/4 .
- C. Plastic, Pop-up Spray Sprinklers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Description:
 - a. Body Material: ABS.
 - b. Nozzle: ABS.
 - c. Retraction Spring: Stainless steel.
 - d. Internal Parts: Corrosion resistant.
 - e. Pattern: Fixed, with flow adjustment.
 - 3. Capacities and Characteristics:
 - a. Nozzle: ABS.

- b. Flow: Per system requirements.
- c. Pop-up Height: 6 inches to 18 inches aboveground to nozzle.
- d. Arc: as required to provide even coverage without overspray.
- e. Radius: Provide head-to-head coverage.
- f. Inlet: NPS 1/2 or NPS 3/4 .

2.9 QUICK COUPLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.
 - 1. Locking-Top Option: Vandal-resistant locking feature. Include two matching key(s).

2.10 DRIP IRRIGATION SPECIALTIES

- A. Continuously self-flushing, pressure-compensating drip line with internal check valves specifically manufactured for landscape applications. Drip tubing shall be 16-17 mm (outside diameter), shall consist of 5/8-inch (nominal) low density, linear polyethylene tubing housing internal pressure-compensating, continuously self-flushing, integral drip emitters with check valves, and shall have insert fittings made by the same manufacturer. The emitters should have the ability to independently regulate discharge rates, with an output pressure of between 9-50 psi at a constant flow. The emitters shall be spaced at 18 inches and have discharge rates of 0.6 gallons per hour for planting areas, utilizing a combination turbulent flow/reduced pressure cell mechanism and a diaphragm to maintain uniform discharge rates. The emitters shall continuously clean themselves while in operation. In groundcover and shrub beds, the drip line shall have the 0.6 gph emitters spaced 18 inches apart with approximately 18 inches spacing between rows providing the precipitation rate of approximately 0.4 inches per hour.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Irritrol Systems.
 - 2. Netafim USA.
 - 3. Rain Bird Corporation.
 - 4. Toro Company (The).
 - 5. Approved Equal.
- C. Drip Tubes with Direct-Attached Emitters:
 - 1. Tubing: Flexible PE or PVC with plugged end.
 - 2. Emitters: Devices to deliver water at approximately 20 psig .
 - a. Body Material: PE or vinyl, with flow control.
 - b. Mounting: Inserted into tubing at set intervals.
- D. Off-Ground Supports: Plastic stakes.
- E. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 , with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig .

- F. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
- G. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
- H. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
- I. Flush valves, often two: one at the far end of each zone, and air relief valves, at high points of each zone, shall be manufactured specifically for use with drip irrigation applications.

2.11 CONTROLLERS

- A. Two-wire Decoder Controller.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- C. Description:
 - 1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
 - 2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
 - a. Body Material: Enameled-steel sheet metal.
 - b. Mounting: Surface type for wall.
 - 3. Interior Control Enclosures: NEMA 250, Type 12, drip-proof, with locking cover and two matching keys.
 - a. Body Material: Enameled-steel sheet metal.
 - b. Mounting: Surface type for wall.
 - 4. Contractor shall provide one remote transmitter/receiver kit per controller and all necessary accessories for users to communicate remotely with the control unit. Receiver mounting location(s) to be coordinated with the Owner.
 - 5. Control Transformer: 24-V secondary, with primary fuse.
 - 6. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
 - a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
 - 7. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
 - 8. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

- a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
9. Concrete Base: Reinforced precast concrete not less than 36 by 24 by 4 inches thick, and 6 inches greater in each direction than overall dimensions of controller. Include opening for wiring.

2.12 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Nationwide Plastics, Inc.
 - d. NewBasis.
 - e. Oldcastle, Inc.
 - f. Orbit Irrigation Products, Inc.
 - g. USFilter/Plymouth Products, Inc.
 - h. Approved Equal.
- 2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.
 - b. Shape: Rectangular.
 - c. Sidewall Material: PE, ABS, or FRP.
 - d. Cover Material: PE, ABS, or FRP.
 - 1) Lettering: " IRRIGATION."

- B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
- B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.
- C. Drain Pockets: Excavate to sizes provided on shop drawings. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches, to 12 inches below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
- D. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of 36 inches below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
2. Circuit Piping: 12 inches .
3. Drain Piping: 12 inches .
4. Sleeves: 24 inches .

3.2 PREPARATION

- A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

3.3 PIPING INSTALLATION

- A. Location and Arrangement: Shop Drawings shall indicate location and arrangement of piping systems. Install piping as indicated.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.
- G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 or larger pipe connection.
- H. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- I. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.
- J. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
- K. Install piping in sleeves under parking lots, roadways, and sidewalks.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 VALVE INSTALLATION

- A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.
- B. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.
- C. Throttling Valves: Install in underground piping in boxes for automatic control valves.
- D. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 SPRINKLER INSTALLATION

- A. Install sprinklers after hydrostatic test is completed.
- B. Install sprinklers at manufacturer's recommended heights.
- C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.7 DRIP IRRIGATION SPECIALTY INSTALLATION

- A. Install freestanding emitters on pipe riser to mounting height indicated.
- B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.
- C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.
- D. Install drip tubes with direct-attached emitters on ground.
- E. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.
- F. Install off-ground supports of length required for indicated mounted height of device.
- G. Install application pressure regulators and filter units in piping near device being protected, and in control-valve boxes.
- H. Install air relief valves and vacuum relief valves in piping, and in control-valve boxes.

3.8 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

- A. Equipment Mounting: Install interior controllers on wall. Coordinate final location with Owner.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Equipment Mounting: Install exterior controllers on building wall. Coordinate final location with Owner.
 - 1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- D. Install control cable in same trench as irrigation piping and at least 2 inches below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.9 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221113 "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
- C. Connect wiring between controllers and automatic control valves.

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Any irrigation product will be considered defective if it does not pass tests and inspections.

- D. Prepare test and inspection reports.

3.11 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that controllers are installed and connected according to the Contract Documents.
 - 3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.12 ADJUSTING

- A. Adjust settings of controllers.
- B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
- C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.
- D. Adjust all sprinkler heads for optimum performance and to prevent over-spray onto paving and structures.

3.13 CLEANING

- A. Flush dirt and debris from piping before installing sprinklers and other devices.

3.14 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.

3.15 PIPING SCHEDULE

- A. Install components having pressure rating equal to or greater than system operating pressure.
- B. Piping in control-valve boxes may be joined with flanges or unions instead of joints.

END OF SECTION 328400

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes planting soils specified by composition of the mixes.
- B. Related Requirements:
 - 1. Section 129200 "Interior Planters and Artificial Plants" for placing planting soil in planters for live interior plants.
 - 2. Section 129300 "Site Furnishings" for placing planting soil in exterior unit planters.
 - 3. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
 - 4. Section 321443 "Porous Unit Paving" for placing planting-soil fill in porous paving.
 - 5. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
 - 6. Section 329300 "Plants" for placing planting soil for plantings.
 - 7. Section 329500 "Vegetated Roof Assemblies" for growing media (soil).
 - 8. Section 329600 "Transplanting" for placing planting soil in tree planting pits.

1.3 ALLOWANCES

- A. Preconstruction and field quality-control testing are part of testing and inspecting allowance.

1.4 UNIT PRICES

- A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

1.5 DEFINITIONS

- A. AAPFCO: Association of American Plant Food Control Officials.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.
- C. CEC: Cation exchange capacity.
- D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

- E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.
- F. Imported Soil: Soil that is transported to Project site for use.
- G. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.
- H. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."
- I. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- J. SSSA: Soil Science Society of America.
- K. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- L. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- M. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- N. USCC: U.S. Composting Council.

1.6 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.7 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include recommendations for application and use.
 - 2. Include test data substantiating that products comply with requirements.
 - 3. Include sieve analyses for aggregate materials.
 - 4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:
 - a. Manufacturer's qualified testing agency's certified analysis of standard products.
 - b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
 - c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.
- B. LEED Submittals:

1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
- C. Samples: For each bulk-supplied material, 1-quart volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.
- D. Delivery and Purchase Tickets: Delivery and purchase tickets for each supplied soil type and compost from supplier. Delivery tickets shall include date, time, driver's name, project name, and quantity of material.

1.8 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For each testing agency.
- B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.
- C. Field quality-control reports.

1.9 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.
 1. Laboratories: Subject to compliance with requirements, provide testing by one of the following:
 - a. SGS; 1511 E. Main St.; P.O. Box 175; Belleville, IL 62221.
 - b. Local University Extension Soils Testing Laboratory (University of Missouri, University of Illinois, etc.)
 2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.10 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil.
 1. Notify Landscape Architect seven days in advance of the dates and times when laboratory samples will be taken.
- B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
 1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.11 SOIL-SAMPLING REQUIREMENTS

- A. General: Extract soil samples according to requirements in this article.
- B. Sample Collection and Labeling: Have samples taken and labeled by Contractor under the direction of the testing agency.
 - 1. Number and Location of Samples: Minimum of three representative soil samples from varied locations for each soil to be used or amended for landscaping purposes.
 - 2. Procedures and Depth of Samples: Per testing laboratory directions.
 - 3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
 - 4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.12 TESTING REQUIREMENTS

- A. General: Perform tests on soil samples according to requirements in this article.
- B. Physical Testing:
 - 1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
 - a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
 - b. Hydrometer Method: Report percentages of sand, silt, and clay.
- C. Chemical Testing:
 - 1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
- D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:
 - 1. Percentage of organic matter.
 - 2. CEC, calcium percent of CEC, and magnesium percent of CEC.
 - 3. Soil reaction (acidity/alkalinity pH value).
 - 4. Buffered acidity or alkalinity.
 - 5. Nitrogen ppm.
 - 6. Phosphorous ppm.
 - 7. Potassium ppm.
 - 8. Manganese ppm.
 - 9. Manganese-availability ppm.
 - 10. Zinc ppm.
 - 11. Zinc availability ppm.
 - 12. Copper ppm.
 - 13. Sodium ppm and sodium absorption ratio.
 - 14. Soluble-salts ppm.

15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
 16. Other deleterious materials, including their characteristics and content of each.
- E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
- F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. for 6-inch depth of soil.
 2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. for 6-inch depth of soil.

1.13 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.
- B. Bulk Materials:
1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Do not move or handle materials when they are wet or frozen.
 4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
 5. Topsoil and/or planting soil stockpile(s) shall be formed under normal industry standards. Stockpile height shall not exceed highest point of lifting mechanism of equipment (maximum height: 72 inches; maximum width: 12') creating the stockpile. Stockpile will be considered defective if equipment drives or otherwise compacts stockpile. Do not stockpile within protection zones.

PART 2 - PRODUCTS

2.1 PLANTING SOILS SPECIFIED BY COMPOSITION

- A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

- B. Planting-Soil Type: Existing, on-site surface soil, with the duff layer, if any, retained; modified to produce viable planting soil. Blend existing, on-site surface soil with the soil amendments and fertilizers in the quantities recommended by the testing agency to produce planting soil.
- C. Planting-Soil Type: Imported, naturally formed soil from off-site sources and consisting of silt loam soil, according to USDA textures; and modified to produce viable planting soil.
 - 1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, bermuda grass, cuttings and/or rhizomes, zoysia grass, and brome grass.
 - 2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 2 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
 - 3. Unacceptable Properties: Clean soil of the following:
 - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
 - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
 - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches in any dimension.
 - 4. Amended Soil Composition: Blend imported, unamended soil with the soil amendments and fertilizers in the quantities recommended by the testing agency to produce planting soil.
- D. Planting-Soil Type: Structural Soil. Cornell University Structural Soil as indicated on drawings.

2.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
 - 2. Class: O, with a minimum of 95 percent passing through a No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.
 - 3. Form: Provide lime in form of ground calcitic limestone.
- B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

- D. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33/C 33M.

2.3 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
 - 1. Feedstock: Limited to leaves and other green waste (grass clippings, twigs, green food waste etc.).
 - 2. Reaction: pH of 5.5 to 8.
 - 3. Soluble-Salt Concentration: Less than 4 dS/m.
 - 4. Moisture Content: 35 to 55 percent by weight.
 - 5. Organic-Matter Content: 50 to 60 percent of dry weight.
 - 6. Particle Size: Minimum of 98 percent passing through a 1-inch sieve.
- B. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
 - 1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. of loose sawdust or ground bark.
- C. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, persistent herbicides, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
 - a. Poultry based litter.
 - b. Approved equal.
- D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

- A. Place planting soil and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

- A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches and stockpile until amended.
- B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
- C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.
- D. Screening: Pass unamended soil through a 2-inch sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

- A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
- C. Mixing: Spread unamended soil to total depth indicated on Drawings, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
 - 1. Amendments: Apply soil amendments and fertilizer, except compost, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
 - a. Mix lime or sulfur with dry soil before mixing fertilizer per soil testing recommendations.
 - b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 8 inches in loose depth for material compacted by compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 BLENDING PLANTING SOIL IN PLACE

- A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 6 inches. Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
- C. Mixing: Apply soil amendments and fertilizer, except compost, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
 1. Mix lime and/or sulfur with dry soil before mixing fertilizer per soil testing recommendation.
 2. Mix fertilizer with planting soil no more than seven days before planting.
- D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.
- E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

- A. Application: Apply compost component of planting-soil mix to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 1. Upon delivery at the project site:
 - a. 1 test per 1000 yards of imported topsoil.
 - 1) Test for the following:
 - a) pH.
 - b) CEC.
 - c) Percentage of Organic Matter.
 - d) N-P-K.
 - e) Sodium ppm and sodium absorption ratio.

- f) Soluble Salts ppm.
- g) Soil Texture. Perform the following tests and inspections:

- 2. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each 1000 sq. ft. of in-place soil or part thereof.
 - 3. Post-installation Soil Test:: Provide soil analysis by same laboratory determining pH, CEC, N-P-K, micronutrients, and organic matter.
- B. Soil will be considered defective if it does not pass tests and inspections, or stockpile has not been formed properly per Section 1.
 - C. Prepare test and inspection reports.
 - D. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.7 PROTECTION

- A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection." And drawing sheet G0400.
- B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Vehicle traffic.
 - 4. Foot traffic.
 - 5. Erection of sheds or structures.
 - 6. Impoundment of water.
 - 7. Excavation or other digging unless otherwise indicated.
- C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Landscape Architect and replace contaminated planting soil with new planting soil.

3.8 CLEANING

- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
 - 1. Coordinate with owner the legal disposal of excess subsoil and unsuitable materials.

END OF SECTION 329113

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sodding.
- B. Related Requirements:
 - 1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
 - 2. Section 329500 "Vegetated Roof Assemblies" for areas of turf on roof structures.
 - 3. Section 334600 "Subdrainage" for below-grade drainage of landscaped areas.

1.3 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. Experience: Five years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Lawncare Manager.
 - c. Landscape Industry Certified Lawncare Technician.
 - 5. Pesticide Applicator: State licensed, commercial.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Accompany each delivery of bulk materials with appropriate certificates.

1.9 FIELD CONDITIONS

- A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

- A. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Turf type tall fescue blend with 3 to 5 improved cultivars.

2.2 PESTICIDES

- A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place and mix planting soil in place over exposed subgrade.
 - 1. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:6 with wood pegs spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.5 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches .
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow turf-type tall fescue to a height of 2 to 3 inches .
- D. Turf Post fertilization: Apply Insert type after initial mowing and when grass is dry.
 - 1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.6 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 - 1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.7 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

3.8 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.
- C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

3.9 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
 - 1. Sodded Turf: 30 days from date of Substantial Completion.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Plants.
 - 2. Planting soils.
 - 3. Tree stabilization.
 - 4. Landscape edgings.

- B. Related Sections:

- 1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
 - 2. Section 129200 "Interior Planters and Artificial Plants" for live and artificial interior plants and planters.
 - 3. Section 129300 "Site Furnishings" for exterior unit planters.
 - 4. Section 311000 "Site Clearing" for protection of existing trees and plantings, topsoil stripping and stockpiling, and site clearing.
 - 5. Section 312000 "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
 - 6. Section 329200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
 - 7. Section 334600 "Subdrainage" for below-grade drainage of landscaped areas, paved areas, and wall perimeters.

1.3 UNIT PRICES

- A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

- 1. Unit prices apply to authorized work covered by quantity allowances.
 - 2. Unit prices apply to additions to and deletions from Work as authorized by Change Orders.

1.4 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.
- D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.
- E. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- F. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- G. Finish Grade: Elevation of finished surface of planting soil.
- H. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- I. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- J. Planting Area: Areas to be planted.
- K. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- O. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- P. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- Q. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, including soils.
 - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
 - 2. Plant Photographs: digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Compile photographs for delivery into a single PDF document. Each plant shall utilize one "letter" sized sheet (8.5" x 11") and include the following information:
 - a. Color Photograph with multi-colored scale rod or adult
 - b. Full Latin and common name of plant.
 - c. Size of plant.
 - d. Name of growing nursery.
 - e. City, State of nursery.
- B. Root ball stabilization products.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified landscape Installer. Provide 3 references of projects similar in size, scope and expected craftsmanship as those shown in the Contract Documents. Include photographs demonstrating Installer's capabilities and experience. Provide project name, address, year completed, and owner's or general contractor's name and current contact information.
- B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
 - 1. Manufacturer's certified analysis of standard products.
 - 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- C. Material Test Reports: For existing native surface topsoil and imported or manufactured topsoil.
- D. Warranty: Sample of special warranty.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. Experience: Ten years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements." Landscape Contractor shall be approved by Owner.
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation specialty area(s), designated CLT-Exterior.
 - b. Certified Landscape Technician - Interior, designated CLT-Interior.
 - c. Certified Ornamental Landscape Professional, designated COLP.
- B. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Landscape Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for plant growth.
 - a. Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
- D. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- E. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- F. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Landscape Architect of sources of planting materials seven days in advance of delivery to site.

G. Preinstallation Conference: Conduct conference at Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

C. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.

G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.9 PROJECT CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

- B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of each service or utility.
 - 2. Do not proceed with interruption of services or utilities without Owner's written permission.
- C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Trees/Shrubs:
 - a. Spring: March 1 – May 31
 - b. Fall: September 1 – December 15
 - 2. Perennials/Groundcover:
 - a. Spring: March 1 – May 31
 - b. Fall: September 1 – October 15
- D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
 - 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.
- F. Coordinate installation of trees in permeable pavement and structural soil with paving contractor. Once trees are placed in the planting pit limit time tree roots are exposed prior to backfilling, establishing finish grade, and mulching, to less than one work day.
 - 1. Trees shall not be stored in place in the tree pits for longer than one work day without prior written consent from owner's representative/landscape architect. Root ball and tree roots must be protected from desiccation at all times, burlap alone is not sufficient protection, provide mulch and/or planting soil to protect sides and top of root ball. Water as required to maintain moist but not wet condition until planting can be completed.

1.10 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.
 - c. Faulty performance of tree stabilization.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods from Date of Substantial Completion:
 - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
 - b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
 - c. Annuals: Three months.
3. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.
 - d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

1.11 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
 1. Maintenance Period: 12 months from date of planting completion.
- B. Initial Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
 1. Maintenance Period: Six months from date of planting completion.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
 1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.

- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.
- E. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- F. Annuals: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

2.2 PLANTING SOILS

- A. Planting Soil: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - 1. Mix existing, native surface topsoil with the soil amendments in the quantities recommended by the soil testing agency to produce planting soil.
- B. Planting Soil : Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the soil amendments in the quantities recommended by the soil testing agency to produce planting soil.
- C. Planting Soil: Imported topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs, or marshes.
 - 1. Additional Properties of Imported Topsoil or Manufactured Topsoil: Screened and free of stones 1 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and brome grass; not infested with nematodes; grubs; or other pests, pest eggs, or other undesirable organisms and disease-causing plant pathogens; friable and with sufficient structure to give good tilth and aeration. Continuous, air-filled pore space content on a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Soil shall have a field capacity of at least 15 percent on a dry weight basis.

2. Mix imported topsoil or manufactured topsoil with the soil amendments in the quantities recommended by the soil testing agency to produce planting soil.

D. Planting Soil : Structural soil. Cornell University Structural Soil as indicated on Drawings.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood.
2. Size Range: 3 inches maximum, 1/2 inch minimum.
3. Color: Natural.

B. Mineral Mulch: Decorative stone mulch as indicated on drawings.

2.4 TREE STABILIZATION MATERIALS

A. Stakes and Guys:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
2. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes.
3. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
4. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
5. Guy Cables: Five-strand, 3/16-inch-diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8-inch galvanized eyebolts.
6. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Landscape Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting areas to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - 2. Spread planting soil to a depth as indicated on drawings but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
 - 1. Excavate approximately three times as wide as ball diameter for balled and burlapped or container-grown stock.

2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
5. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
6. Maintain supervision of excavations during working hours.
7. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
8. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Subsoil and topsoil removed from excavations may be used as planting soil.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch-diameter holes, 24 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.

1. Use planting soil for backfill.
2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
4. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Set container-grown stock plumb and in center of planting pit or trench with root flare 1 inch above adjacent finish grades.

1. Use planting soil for backfill.
2. Carefully remove root ball from container without damaging root ball or plant.

3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 4. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE STABILIZATION

- A. Install trunk stabilization as follows unless otherwise indicated:
1. Upright Staking and Tying: Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend at least 72 inches above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
 2. Use two stakes for trees up to 12 feet high and 2-1/2 inches or less in caliper; three stakes for trees less than 14 feet high and up to 5 inches in caliper. Space stakes equally around trees.
 3. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
 4. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
- B. Staking and Guying: Stake and guy trees more than 14 feet in height and more than 3 inches in caliper unless otherwise indicated. Securely attach no fewer than three guys to stakes 30 inches long, driven to grade.
1. Site-Fabricated Staking-and-Guying Method:
 - a. For trees more than 6 inches in caliper, anchor guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle for each guy wire and tighten securely.
 - b. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - c. Support trees with strands of cable or multiple strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle. Allow enough slack to avoid rigid restraint of tree.
 - d. Attach flags to each guy wire, 30 inches above finish grade.
 - e. Paint turnbuckles with luminescent white paint.
- C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting in permeable pavement planting pits by the root ball unless otherwise indicated.

3.7 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on drawings in even rows with triangular spacing.

- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.
- E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.8 PLANTING AREA MULCHING

- A. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees and Tree-like Shrubs in Turf Areas: Apply organic mulch ring of 2-inch average thickness, with 36-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
 - 2. Organic Mulch in Planting Areas: Apply 2-inch average thickness of organic mulch extending 12 inches beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.9 EDGING INSTALLATION

- A. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch-deep, shovel-cut edge.

3.10 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

3.11 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

**Interdisciplinary Science Building
Webster University
Cannon Design Project No. 004561.01**

- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.12 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 329300

SECTION 329500 - VEGETATED ROOF ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Continuous vegetated roof assemblies.
- B. Related Sections:
 - 1. Section 071413 "Hot Fluid Applied Waterproofing" for membrane roofing, roof insulation, aggregate or roof-paver ballast, and membrane roofing warranty.
 - 2. 329200_Turf and Grasses

1.3 DEFINITIONS

- A. Captured Water: Water that is retained in the drainage layer of a vegetated roof assembly after new water additions have ceased and that cannot escape the roof except through evaporation or plant transpiration.
- B. Finish Elevation: Elevation of finished growing-media surface of planting area.
- C. Planting Area: Areas to be planted.
- D. Plant, Plants, Plant Material: Vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- E. Growing Medium: Manufactured, lightweight soil mixture that promotes good growing conditions for specific varieties of plants.

1.4 ACTION SUBMITTALS

- A. Product Data: For each vegetated roof assembly and each component, including each growing medium.
- B. Samples for Verification: For each of the following components of vegetated roof assembly:

1. Growing Media: 1-quart volume of each growing medium, in sealed plastic bags labeled with content and source. Each Sample shall be typical of the lots of growing media to be furnished. Provide an accurate representation of texture and composition.
2. Molded-Sheet Drainage Panels: 12 by 12 inches .
3. Protection Fabric: 12 by 12 inches .
4. Drainage Gravel: 1-quart volume in sealed plastic bags labeled with content and source.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
 1. Manufacturer's certified analysis of standard products.
 2. Analysis of other materials by a recognized laboratory, according to methods established by the Association of Official Analytical Chemists, where applicable.
- C. Product Test Reports: For each growing medium, including complete analysis demonstrating compliance with specified requirements.
- D. Field quality-control reports.
- E. Warranty: Sample of each special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended maintenance plan including procedures for inspection and care of vegetated roof assembly and plants during a calendar year. Submit before start of required warranty and maintenance periods.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified vegetated roof assembly Installer with 10 years' experience, approved, authorized, or licensed by membrane roofing manufacturer, whose work has resulted in successful establishment of vegetated roofs.
 1. Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 2. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 3. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation specialty area, designated "CLT-Exterior."
 - b. Certified Ornamental Landscape Professional, designated "COLP."
- B. Source Limitations: Obtain vegetated roof assembly components, growing medium, and accessories from single source from single manufacturer.

- C. Preinstallation Conference: Conduct conference at Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials on or near structures, utilities, walkways and pavements, or existing roof areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of debris-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk materials with product certificates.

1.9 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTIES

- A. Special Warranty for Vegetated Roof Assembly: Installer agrees to repair or replace vegetated roof assembly and components that fail in materials or workmanship within specified warranty period.
 - 1. Failure includes, but is not limited to, ponding water or prolonged wetness of growing medium caused as a result of failure of the assembly to properly drain.
 - 2. Warranty Period: 10 years from date of Substantial Completion.
- B. Special Warranty for Plant Growth: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 - 1. Foliage Cover: Planted materials shall grow to achieve and maintain at least 100 percent foliage cover over planting area commencing immediately after planting, through the duration of this warranty and shall include at least one full winter season.
 - 2. Failures include, but are not limited to, death and unsatisfactory growth except for defects resulting from abuse, lack of adequate maintenance, neglect by Owner, or incidents that are beyond Contractor's control.
 - 3. Warranty Periods from Date of Substantial Completion:
 - a. Turf Grass: One year.
 - 4. Include the following remedial actions as a minimum:
 - a. See section 329200 "Turf and Grasses"

1.11 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Provide maintenance by skilled employees of vegetated roof assembly Installer approved by membrane roofing manufacturer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than the following maintenance period:
1. Maintenance Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 VEGETATED ROOF ASSEMBLY COMPONENTS

- A. Drainage Products:
1. Molded-Sheet Drainage Panels: Manufacturer's standard drainage board formed from geotextile-faced, molded-plastic sheet with a geotextile face and "cups" of the molded sheet facing upward like small reservoirs to retain water while allowing excess water to drain away below the board.
- B. Aggregate-Type Moisture-Retention and Drainage Products:
1. Protection Fabric: Manufacturer's standard protection fabric.
 2. Drainage Gravel: Washed, sound crushed stone or gravel per drawings ASTM D 448 for Size No. 8.

2.2 VEGETATED ROOF ASSEMBLIES

- A. Continuous Vegetated Roof Assembly: Continuous-coverage assembly consisting of manufacturer's standard vegetated roof assembly components for installation over membrane roofing.
1. Products: Subject to compliance with FLL Guidelines, current edition, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Hydrotech, Inc; Intensive Garden Roof.
 - b. Firestone Building Products; SkyScape Multilayer System.
 - c. Roofscapes, Inc.; Roofmeadow.
 - d. CETCO; GreenScape Green Roof Solutions.
 - e. Approved Equal.
 2. Assembly Depth, Nominal: As shown on Drawings, including growing medium.
 3. Assembly Weight: Maximum [~~15 lb/sq. ft.~~][**28 lb/sq. ft.**]<Insert requirement>, including growing medium and plants and saturated with captured water, but not including weight of roofing system.
 4. Plantings: As shown on Drawings.

2.3 MANUFACTURED GROWING MEDIA

- A. Growing Medium: Vegetated roof assembly manufacturer's lightweight, manufactured soil mixture designed for turf grass.

1. Products: Subject to compliance with requirements.
2. General Condition at Time of Planting: Free of stones 1/2 inch or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of weeds and other botanical pests; not infested with nematodes, grubs, or other pests or pest eggs; free of disease-causing plant pathogens and other undesirable organisms; friable and with sufficient structure to give good tilth and aeration.
3. Maximum Media Density: ASTM E 2399, ~~<insert weight> lb/cu. ft.~~ for basic growing-medium mixture.
4. Maximum Media Water-Retention: ASTM E 2399, ~~<insert number>~~ percent by volume for basic growing-medium mixture at maximum media density.
5. Water Permeability: ASTM E 2399, ~~<insert number> in/min.~~ for basic growing-medium mixture at maximum media density.
6. Organic Material Content: ASTM F 1647, Method A, organic material as measured using the loss-on-ignition procedure.
 - a. Minimum: 4 percent.
 - b. Maximum: 10 percent.
7. Chemical Properties:
 - a. Growing-Medium pH (Reaction): Value of 5.5 to 7.0.
 - b. Cation Exchange Capacity: Minimum 20 meq/100 g of growing medium.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine each area to receive vegetated roof assembly for compliance with requirements for installation tolerances and other conditions affecting performance.
 1. Verify that roof insulation over membrane roofing is in place, secure, and flush along all seams.
 2. Verify that perimeter and other flashings are in place and secure along entire lengths where they will be covered by vegetated roof assembly.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Inspect growing medium. If growing medium is contaminated by foreign or deleterious material or liquid, remove growing medium and contamination and replace with new growing medium.

3.2 PREPARATION

- A. General: Protect structures, utilities, sidewalks, pavements, and other facilities and areas from damage caused by installation.
- B. Protection Course: Cover membrane roofing with protection board with butted and fully taped joints before membrane roofing is subject to vegetated roof assembly installation work.

3.3 INSTALLATION, GENERAL

- A. Install vegetated roof assembly according to manufacturer's written instructions.

3.4 PLANTING

- A. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in growing medium within a planting area.
- B. Do not mix or place growing medium during frozen, wet, or muddy conditions.
- C. Suspend spreading, grading, and planting operations during periods of excessive moisture until the moisture content in growing medium reaches acceptable levels to attain the required results.
- D. Uniformly moisten an excessively dry growing medium that is too dusty or not workable.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage membrane roofing manufacturer's authorized service representative to provide full-time inspection of vegetated roof assembly installation and prepare inspection reports.
- B. Correct deficiencies in work that do not comply with requirements.

3.6 PLANT MAINTENANCE

- A. General: During maintenance period, maintain turf per section 329200_Turf and Grasses. Spray or treat as required to keep turf grass free of insects and disease.
- B. Replace growing medium that becomes displaced or eroded because of settling or other processes.
- C. Apply treatments as required to keep plant materials, planted areas, and growing medium free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
- D. Use only products and methods acceptable to membrane roofing manufacturer.

3.7 CLEANING AND PROTECTION

- A. During planting and maintenance, keep adjacent areas and construction clean and maintain work area in an orderly condition.
- B. Protect vegetated roof assemblies from damage due to planting operations and operations of other contractors and trades. Repair or replace damaged vegetated roof assemblies.

END OF SECTION 329500

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