PROJECT TITLE PAGE

# PROJECT MANUAL

**ISSUED FOR BID**
**07 OCTOBER 2024**

## THE BOARD OF GOVERNORS OF MISSOURI STATE UNIVERSITY

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**VOLUME 3 OF 3**
**DIVISIONS 20 - 34**

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# SECTION 20 00 00 – BASIC MECHANICAL, PLUMBING, AND FIRE 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.

B. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 21-25 of these Specifications.

C. The following sections of the Specifications apply to Work under this Section.
1. Division 21 – Fire Protection System
2. Division 22 – Plumbing Work
3. Division 23 – HVAC Piping and Equipment
4. Division 24 – Air Distribution
5. Division 25 – Temperature Control System
6. Section 20 05 48 – Seismic Control
7. Section 20 05 49 – Vibration Control
8. Section 20 10 00 – Basic Mechanical Methods
9. Section 20 10 10 – Basic Piping Materials
10. Section 20 10 20 – Valves and Strainers
11. Section 20 10 30 – Hangers, Shields, Supports, and Anchors
12. Section 20 10 40 – Sleeves and Seals
13. Section 20 10 50 – Basic Mechanical Methods – Related Work
14. Section 20 10 60 – Testing Adjusting and Balancing
15. Section 20 10 70 – Identification
16. Section 20 20 10 – Electrical Requirements
17. Section 20 20 10 – Drives and Guards
18. Section 20 20 25 – Insulation

### 1.2 SUMMARY

A. Section Includes: Seismic Control for the work of Divisions 20 - 25.
2. Vibration Control for the work of Divisions 20 - 25.
3. Identification of piping and equipment for the work of Divisions 20 - 25.
4. Testing, adjusting and balancing of systems for the work of Divisions 20 - 25.
5. Cleaning of piping and equipment for the work of Divisions 20 - 25.
6. Excavation, trenching and backfilling for the work of Divisions 20 - 25.
7. Painting of piping and equipment for the work of Divisions 20 - 25.
8. Demolition for the work of Divisions 20 - 25.
9. Concrete for the work of Divisions 20 - 25.

## 1.3 ACTION SUBMITTALS

A. Refer to Division 1 and each section of Division 20.

## 1.4 INFORMATIONAL SUBMITTALS

A. Refer to Division 1 and each section of Division 20.

## 1.5 CLOSEOUT SUBMITTALS

A. Refer to Division 1 and each section of Division 20.

## PART 2 - PRODUCTS (Not Applicable)

## PART 3 - EXECUTION (Not Applicable)

END OF SECTION 20 00 00

# SECTION 20 05 48 – SEISMIC CONTROLS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Restraints - rigid type.
   2. Restraints - cable type.
   3. Restraint accessories.
   4. Post-installed concrete anchors.
   5. Concrete inserts.

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 DEFINITIONS

A. Designated Seismic System: A Fire Protection, Plumbing, or HVAC component that requires design in accordance with ASCE/SEI 7, Ch. 13 – Seismic Design for Nonstructural Components, and as required by local code, and as a required on the Drawings.

B. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to in this subparagraph is the edition intended as reference throughout the Section Text is ASCE/SEI 7-10 including supplement No. 1 .

C. IBC: International Building Code.

D. ICC-ES: ICC Evaluation Service, LLC. A Subsidiary of the International Code Council.

E. Seismic Listing Agency: ICC-ES product listing, UL product listing, FM Approvals, an evaluation service member of ICC-ES, an agency acceptable to authorities having jurisdiction.

F. Professional Engineer: Professional Engineer registered in the state of Missouri.

### 1.3 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. Include load rating for each wind-force-restraint fitting and assembly.
   3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-and wind-force-restraint component.

4. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by a Seismic Listing Agency.
5. Annotate to indicate application of each product submitted and compliance with requirements.
6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.
2. 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.

C. Delegated Design Submittals:
1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
2. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
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 by professional engineer that riser system was examined for excessive stress and that none exists.
4. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
5. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
6. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
7. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified Professional Engineer responsible for their preparation.
8. Seismic-and Wind-Restraint Detail Drawing:
    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 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 also with requirements in other Sections for equipment mounted outdoors.
9. All delegated design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.

10. Product Listing, Preapproval, and Evaluation Documentation: By a Seismic Listing Agency, showing maximum ratings of restraint items and basis for approval (tests or calculations).
11. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
12. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

## 1.4 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

B. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for Fire Protection, Plumbing, and HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

C. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction or experience data as permitted by ASCE/SEI 7.
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

D. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.
3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
4. The following HVAC systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind force and impact damage must be provided by manufacturer:

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

C. As-built seismic drawings with sealed letter from Seismic engineer stating that the completed installation meets the design.

## 1.6 QUALITY ASSURANCE

A. Seismic-and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified Professional Engineer, to design seismic and wind-load control system.
   1. Seismic and Wind-Load Performance: Equipment to withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7.

B. Seismic Design Calculations:
   1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7.
   2. Data indicated below to be determined by Delegated Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
   3. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.
   4. See drawings for Building Occupancy Category, Building Risk Category, Building Site Classification and component or system importance factor.
   5. See structural drawings for calculation factors.

C. Consequential Damage: Provide additional seismic restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in ASCE/SEI 7 so that failure of a non-essential or essential HVAC component will not cause failure of any other essential architectural, mechanical, or electrical building component.

D. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

E. Component Supports:
1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7.

## 2.2 MANUFACTURERS

A. Seismic Restraints and Accessories
1. Amber/Booth
2. Eaton
3. Gripple
4. Isotech
5. Kinetics Noise Control
6. Loos & Co., Inc.
7. Mason Industries
8. Approved equivalent

B. Post-installed concrete anchors.
1. Concrete Fastening Systems
2. Hilti
3. ITW Red Head
4. MKT
5. Powers
6. Simpson Strong-Tie
7. Approved equivalent

## 2.3 RESTRAINTS - RIGID TYPE

A. Source Limitations: Obtain rigid-type restraints from single manufacturer.

B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes 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.

## 2.4 RESTRAINTS - CABLE TYPE

A. Source Limitations: Obtain cable-type restraints from single manufacturer.

B. Seismic-Restraint Cables: Pre-stretched galvanized-steel aircraft cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.5 RESTRAINT ACCESSORIES

A. Source Limitations: Obtain restraint accessories from single manufacturer.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod. Non-metallic stiffeners are unacceptable.

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.

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

2.6 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. Source Limitations: Obtain mechanical anchor bolts from single manufacturer.
2. 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 for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:
1. Source Limitations: Obtain adhesive anchor bolts from single manufacturer.
2. 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 E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16, Ch. 13.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

## 2.7 CONCRETE INSERTS

A. Source Limitations: Obtain concrete inserts from single manufacturer.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind 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 a Seismic Listing Agency.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on the Seismic 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, wind load, and seismic loads within specified loading limits.

## 3.3 INSTALLATION OF SEISMIC- AND WIND RESTRAINT DEVICES

A. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated on the Drawings, where indicated on the Seismic Drawings, where Specifications indicate they are to be installed on equipment and systems, and where required by applicable codes.

B. Install seismic-restraint devices using methods approved in accordance with their listing and manufacturer’s instructions.

C. Coordinate 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."

D. Installation of seismic, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

F. Equipment Restraints:

1. 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.
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, and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. 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.

H. Ductwork Restraints:

1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." and ASCE/SEI 7.
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.
4. Select seismic-restraint devices with capacities adequate to carry static and seismic loads.
5. Install cable restraints on ducts that are suspended with vibration isolators.

I. Install seismic-and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

K. 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.

L. 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.

M. Mechanical Anchor Bolts:

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 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-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: 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.

N. Aircraft cable installation:
1. Cable tails shall not exceed 2x manufacturers minimum requirements.
2. In finished spaces exposed to view
    a. Top connection shall be integrated fastener or tab. Hooks, loops, ring anchor, carabiner types shall not be used.

## 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements for piping flexible connections.

END OF SECTION 20 05 48

# SECTION 20 05 49 – VIBRATION CONTROLS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Elastomeric isolation pads.
1. Housed-spring isolators.
2. Resilient pipe guides.
3. Elastomeric hangers.
4. Spring hangers.
5. Vibration isolation equipment bases.
6. Restrained isolation roof-curb rails.

B. Related Requirements:
1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 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. 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.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

B. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for Fire Protection, Plumbing, and HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Where vibration isolation products are Restrained Type used on equipment or systems that are required to be seismically restrained, follow the additional requirements of 20 05 48 Seismic Controls.

### 2.2 MANUFACTURERS

A. Vibration Isolation Products:
1. Amber/Booth
2. Isotech
3. Kinetics Noise Control
4. Korfund
5. Mason Industries
6. Thybar
7. Vibra Systems
8. VMC Group
9. Approved equivalent

### 2.3 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Source Limitations: Obtain elastomeric isolation pads from single manufacturer.
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. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.

### 2.4 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Source Limitations: Obtain freestanding, laterally stable, open-spring isolators in two-part telescoping housing from single manufacturer.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases limit floor load to 500 psig.

b. Top housing with attachment and leveling bolt.

## 2.5 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch-Thick Neoprene:
1. Source Limitations: Obtain resilient pipe guides from single manufacturer.
2. Factory-Set Height Guide with Shear Pin: Shear pin to be removable and reinsertable to allow for selection of pipe movement. Guides to be capable of motion to meet location requirements.

## 2.6 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
1. Source Limitations: Obtain elastomeric hangers from a single manufacturer.
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. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

## 2.7 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Source Limitations: Obtain spring hangers from single manufacturer.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Retain "Adjustable Vertical Stop" Subparagraph below if a vertical-limit stop is required.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind 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 INSTALLATION OF VIBRATION-CONTROL DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

E. 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.

F. Mechanical Anchor Bolts:
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 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-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors to be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: 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.

## 3.3 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

B. Coordinate dimensions of steel equipment rails and bases, concrete inertia bases, and restrained isolation roof-curb rails with requirements of isolated equipment specified in this and other Sections. Where dimensions of these bases are indicated on Drawings, dimensions may require adjustment to accommodate actual isolated equipment.

## 3.4 ADJUSTING

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring 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.

END OF SECTION 20 05 48

# SECTION 20 10 00 – BASIC MECHANICAL MATERIALS AND METHODS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Arrangement of Work
   2. Coordination
   3. Delivery, Storage and Handling
   4. General Cleaning
   5. Cleaning of Piping Systems
   6. Pressure Testing

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

## PART 2 - PRODUCTS (Not Applicable)

## PART 3 - EXECUTION

### 3.1 ARRANGEMENT OF WORK

A. All Work shall be arranged so that hangers and supports for the mechanical equipment and materials shall be within the load limitations of the structure and the respective hanger and/or support.

B. Contractor shall not scale from drawings to determine the exact locations for devices, piping, ductwork, etc., but shall follow the architectural drawings, the structural drawings and the actual building conditions, in establishing dimensions and lines of run. The work shall be adjusted to accommodate interferences anticipated and encountered. The Contractor shall verify the exact material quantities and lengths required.

C. Piping that is required to pitch shall have priority over piping that does not pitch. Work which cannot be changed in elevation shall have priority over that which can be moved. Offsets, transitions and changes in direction shall be made in piping and ductwork to maintain headroom and pitch whether or not indicated on the Plans. The Contractor shall provide air vents, traps, dirt legs, drains, lifts, sanitary vents, mechanical vent lines, etc. as required to install the mechanical systems for proper operation and maintenance.

D. Do not install work in the immediate proximity of electrical components (e.g. - panels, switches, controls, boxes, etc.) in equipment rooms. Drip pans above and/or around electrical equipment are not permitted.

E. Aluminum and copper products shall not be encased in concrete.

F. Work in “finished spaces” shall be concealed within walls, chases or above the ceiling unless specifically indicated otherwise. Install the Work to coordinate with other trades and to conform to the architectural reflected ceiling plan.

G. The work shall be installed parallel with the building lines unless specifically shown or noted otherwise.

3.2 COORDINATION

A. Each Contractor shall prepare and submit coordination drawings (at a scale equal to or larger than the project documents) to the Architect/Engineer for review prior to any fabrication or installation.

B. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations included in different Sections that depend on each other for proper installation, connection, and operation.
1. Schedule construction operations in sequence required to obtain the best results, where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

C. It shall be the Contractor's responsibility to coordinate their work with the work of other trades, and with the architectural and structural drawings. Where physical interferences cannot be resolved between the trades, or when encountered in the field, the Contractor shall prepare composite drawings at a scale of not less than 3/8” = 1'-0” clearly showing the Work of Divisions 20 - 29 in relation to the Work of others to identify the conflict. Submit a proposed resolution to the Architect/Engineer for approval.
1. Do not proceed with Work in question until the matter is mutually resolved among the involved parties, and adequate information has been submitted to the Architect/Engineer for review. No additional compensation shall be granted for modifications and execution of the resolution(s). Modifications are to be incorporated in the “as-built” drawings.

D. Contractor shall review the Project Documents, site conditions, and the requirements of other disciplines, and shall report any discrepancies between them to the Architect/Engineer and obtain from him written permission for changes necessary in the Mechanical Work. Subsequent clarification(s) by the Architect/Engineer will not be a change in scope of the Work. The Contractor at no addition in the contract price shall perform any such modifications required.

E. Contractor shall verify tie-in locations to verify sizes, direction of flow (via pressure or physical tracing, not labels), materials, elevations, etc. prior to commencing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

F. The drawings shall not be scaled; obtain detailed information, shop drawings, installation and maintenance bulletins, etc. to determine exact requirements and to satisfactorily achieve the intent of the Project Documents.

G. The Contractor shall furnish and properly install all sleeves, slots, chases, openings, recesses, supports, anchors and anchor bolts required for his Work in coordination with the other trades as the building is erected.

H. The expenses for changes required by neglect in executing, coordinating or scheduling the Work properly or avoiding conflicts shall be borne by the Contractor precipitating the issue requiring the changes.

## 3.3 DELIVERY, STORAGE AND HANDLING

A. Delivery, storage and handling of equipment and material are the Contractor's responsibilities. The Contractor shall perform the Work in accordance with the following criteria:
   1. Delivery shall be arranged by the Contractor (including Owner furnished items) for the expeditious and economical pursuit of the Work and to meet the scheduling requirements of the Contract.
   2. The Contractor will be assigned a “lay-down” area at the job site and shall confine temporary storage to this area.
   3. The Contractor may take delivery of equipment and material at his “shop” or an off-site location as suits the performance and schedule of the Work.
   4. Regardless of where and how equipment and material are temporarily stored prior to installation, or if installed at the job site prior to acceptance, the Contractor is responsible for the following:
      a. All equipment and material shall be accessible to the Architect/Engineer for inspection.
      b. All equipment and material shall be protected adequately and properly from the weather, dirt and water, chemical, mechanical or comprehensive damages.
      c. The Contractor shall be liable for the repair and/or replacement (including labor) of any equipment and material lost, damaged or defective prior to acceptance.
   5. The Contractor shall arrange all labor, tools, services and scheduling to perform the handling of equipment and material for his Work.

## 3.4 GENERAL CLEANING

A. Each Contractor and Subcontractor shall be responsible for progress and final clean-up of his respective Work in accordance with the Contract Documents, requisite ordinances and regulations. Clean-up and legal disposal of debris from the Work, excess refuse and presence at the job site shall be performed in a timely and satisfactory manner. If not, the Contractor shall be notified of the unsatisfactory condition. If the matter persists, the Contractor will be back charged for the clean-up performed by others.

B. Clean exposed exteriors and limited access interior surfaces of all equipment, piping and ductwork of foreign matter to provide an “as new” condition.

## 3.5 CLEANING OF PIPING SYSTEMS

A. The Contractor shall clean the respective piping system(s) that are included in his scope of work. All systems shall be flushed with water or air (depending on ultimate use) to relieve any congestion and internally cleanse the respective piping system. The Contractor shall provide all flushing media in sufficient quantity, inlet connections, discharge or drainage outlets and any temporary provisions to protect components, or remove it, to facilitate the flushing. Clean and replace all strainer screens and filters. Flush clean and drain all low points in the piping.

B. Owner's representative shall be present for flushing, cleaning, and rinsing. Water treatment representative must check water after rinsing to insure all chemical cleaner has been removed and the Alkalinity of the rinse water is equal to that of the make-up water.

C. All pipe systems for hydronic applications including non-potable water system shall be flushed continuously with 100% city water make-up until the water runs clean from all drain locations. Each piping system shall be subsequently cleaned with recommended dosage of an approved pre-cleaning chemical designed to remove deposition such as pipe dope, oils, loose rust, mill scale and other extraneous materials for a minimum period of twenty-four (24) hours then drained, refilled, and rinsed clean. Flushing before and rinsing after cleaning shall be supplying constant make-up water while draining at all system low points and drains.

D. Steam and condensate return piping shall be flushed continuously with 100% city water make-up until the water runs clean from all drain locations. Each piping system shall be subsequently cleaned with recommended dosage of an approved pre-cleaning chemical designed to remove deposition such as pipe dope, oils, loose rust, mill scale and other extraneous materials for a minimum period of twenty-four (24) hours then drained, refilled, and rinsed clean. Flushing before and rinsing after cleaning shall be by supplying constant make-up water while draining at all system low points and drains.

E. New or repaired potable water systems shall be purged of deleterious matter and disinfected prior to utilization. The method to be followed shall be that prescribed by the health authority having jurisdiction or, in the absence of a prescribed method, the procedure described in either AWWA C651 or AWWA C652, or as described in this section. This requirement shall apply to "on-site" or "in-plant" fabrication of a system or to a modular portion of a system.

F. Document the materials, the chemicals to be used, the concentration in ppm, the contact time and who is performing the work. Document the date, time and data from the entire flushing and disinfection process and keep records to show that such processes were performed.
   1. Locate chemical injection points and flushing locations.
   2. Pre-mix disinfection chemicals in tanks or establish a flow-proportioning pump that can be accurately controlled with a chlorine meter.
   3. Establish a procedure for flushing water at every fixture, a required number of simultaneous fixtures to be flushed and a schedule of flushing times.
   4. Turn off the hot water system and flush out hot water that can affect the chemical oxidation rate.
   5. Flush the cold and hot water systems with water at approximately 3 feet/second velocity until the water runs clear at every fixture. This removes dirt, sediment and debris.
   6. Fill the system with a water-chlorine solution; flow water from every fixture until water treatment chemical residuals of a sufficient amount are present.
   7. Measure the water treatment chemical residual at remote fixtures at the beginning, at regular intervals and at the end of the contact time period.

G. The pipe system shall be flushed with clean, potable water until dirty water does not appear at the points of outlet.

H. The system or part thereof shall be filled with a water/chlorine solution containing at least 50 parts per million (50 mg/L) of chlorine, and the system or part thereof shall be valved off and allowed to stand for 24 hours; or the system or part thereof shall be filled with a water/chlorine solution containing at least 200 parts per million (200 mg/L) of chlorine and allowed to stand for 3 hours.

I. Following the required standing time, the system shall be flushed with clean potable water until the chlorine is purged from the system.

J. The procedure shall be repeated where shown by a bacteriological examination that contamination remains present in the system.

K. Water quality acceptance test(s) required shall include: Total Coliform, e-coli, pH, Alkalinity, Turbidity. Test potable water from nearby source as a reference sample.

3.6 PRESSURE TESTING

A. Entire piping systems shall be pressure tested at one time unless it is not possible or practical. When partial testing is required, the Contractor shall submit a test plan.

B. All piping to be insulated or concealed shall be pressure tested prior to the application of the insulation or concealment.

C. A representative of the Architect/Engineer shall witness all pressure testing. The Contractor shall notify the Architect/Engineer at least three (3) days prior to the test date.

D. Each piping system shall be tested per the method, test pressure, and test duration as specified in the Piping Application Schedules.

E. The Contractor shall provide all test media, measuring devices, inlet connections, test measurement connections, and disposal of test media. The Contractor shall protect, isolate and/or remove piping system components that can not be subjected to test pressures.

F. Hammer each joint in welded or soldered piping while under test. Leaks shall be repaired and the test(s) repeated until the respective piping system is tight.

G. Prepare written report of testing.

END OF SECTION 20 10 00

# SECTION 20 10 10 – BASIC PIPING MATERIALS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Copper tube and fittings.
   1. Steel pipe and fittings.
   2. Stainless steel pipe and fittings.
   3. Cast iron pipe and fittings.
   4. Ductile iron pipe and fittings.
   5. High Density Polyethene
   6. Piping joining materials.
   7. Transition fittings.
   8. Dielectric fittings.

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

B. Welding certificates.

C. Qualification Data: For Installer.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

### 1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Grooved Joints: Installers are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9 for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

## 1.6 WARRANTY

A. Grooved fittings and couplings Manufacturer's Warranty: Manufacturer agrees to repair or replace couplings and fittings that fail in materials or workmanship within 20 years from date of Substantial Completion.
   1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
   2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system was tested and passed manufacturer's pressure/leak test and any other manufacturer requirements.

# PART 2 - PRODUCTS

## 2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88 types K & L.

B. Annealed-Temper Copper Tube: “Soft” copper tube ASTM B88 type K

C. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

D. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

E. Refrigeration ACR Tube: ASTM B280

F. Cast-Copper, Solder-Joint Fittings: ASME B16.18 pressure fittings.

G. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings.

H. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

I. Cast-Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

J. Wrought-Copper Unions: ASME B16.22.

K. Copper-Tube, Mechanically Formed Tee Fitting: For forming T-branch on copper water tube.
   1. Description: Tee formed in copper tube in accordance with ASTM F2014.

L. Grooved, Mechanical-Joint, Copper Tube Fittings and Couplings
   1. Source Limitations: Obtain grooved mechanical-joint copper tube fittings and couplings from single manufacturer.
   2. Grooved-End Copper Fittings: ASTM B75 (ASTM B75M) copper tube or ASTM B584 bronze castings.
   3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psig (2060 kPa) minimum CWP pressure rating.

M. Solder Filler Metals: ASTM B32, lead-free alloys.

N. Flux: ASTM B813, water flushable.

O. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

## 2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3, "Piping Applications" Article.

B. Steel Pipe: ASTM A106 black steel with plain ends; seamless, Grade A, and schedule number as indicated in Part 3, "Piping Applications" Article.

C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3, "Piping Applications" Article.

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3, "Piping Applications" Article.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping Applications" Article.

F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

G. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.

H. Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

I. "Weldolets, Threadolets, Sockolets and Elbolets": In accordance with ANSI B36.10/ASTM A216, except Elbolets which are ANSI B16.11. Weldolets available standard and extra strong, black only, range 1/8" - 24". Others available 3000# and 6000#, black only, range 1/8" - 4" (limited).

J. Grooved Mechanical-Joint Fittings and CouplingsSource Limitations: Obtain grooved mechanical-joint fittings and couplings from single manufacturer.
   2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts and bolts to secure grooved pipe and fittings. Segmentally welded fittings are not acceptable.
   3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   4. Only the following fittings will be accepted: Long radius (1.5 x diameter) 90° and 45° elbows, tee, reducing tee, concentric/eccentric reducers, and flange adapter nipples. Flange rings, reducing couplings, saddle/mechanical/clamp branch tee, and others not listed above are not acceptable.

K. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

## 2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:
   1. Standards: ASTM A74.
   2. All cast iron soil pipe and fittings shall be 3rd party certified by CISPI or ANSI accredited third party auditing firms to the complete standards, including Annex A1.
   3. Warranty: 5 years
   4. Manufacturers: Charlotte Pipe and Foundry, Tyler Pipe and Coupling, AB&I Foundry.

B. Gaskets: ASTM C564, rubber.

C. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

D. Epoxy coating:
   1. Boring: Interior of pipe to be bored/remained for smoothness prior to coating
   2. Pipe and fitting interior: Minimum 5 mils
   3. Pipe and fitting exterior: Minimum 2.5 mils
   4. Epoxy touch up: Manufacturer to provide product.
   5. Performance Testing: 3rd party testing Per EN 877
      a. Resistance to salt spray
      b. Resistance to wastewater
      c. Chemical resistance
      d. Dry coating thickness
      e. Adhesion
      f. Resistance to hot water

g. Resistance to temperature cycling
6. Warranty: 10 years
7. Manufacturers: Charlotte Pipe and Foundry, Tyler Pipe and Coupling, New Age Castings

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:
1. Standards: ASTM A888, CISPI 301.
2. All cast iron soil pipe and fittings shall be 3rd party certified by CISPI or ANSI accredited third party auditing firms to the complete standards, including Annex A1.
3. Manufacturers: Charlotte, Tyler, AB&I.

B. Epoxy coating:
1. Boring: Interior of pipe to be bored/remained for smoothness prior to coating
2. Pipe and fitting interior: Minimum 5 mils
3. Pipe and fitting exterior: Minimum 2.5 mils
4. Epoxy touch up: Manufacturer to provide product.
5. Performance Testing: 3rd party testing Per EN 877
a. Resistance to salt spray
b. Resistance to wastewater
c. Chemical resistance
d. Dry coating thickness
e. Adhesion
f. Resistance to hot water
g. Resistance to temperature cycling
6. Warranty: 10 years
7. Manufacturers: Charlotte Pipe and Foundry, Tyler Pipe and Coupling.

C. CISPI, Hubless-Piping Couplings:
1. Standards: ASTM C1277 and CISPI 310.
2. Description: Stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
3. Couplings (60 in./lbs) shall be by Anaco/Husky, Ideal Clamps, Tyler Pipe, Mission Rubber Company or approved equivalent

D. Heavy-Duty, Hubless-Piping Couplings:
1. Standards: ASTM C1277 and ASTM C1540.
2. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
3. Heavy duty couplings (80 in./lbs) shall be ASTM C1540: Anaco/Husky HD-2000, Charlotte Heavy Duty ‘MD’, Ideal Heavy Duty, Mission HeavyWeight, Clamp-All Hi-Torque 80, MIFAB X-Hub.

E. Extra Heavy-Duty, Hubless-Piping Couplings:
1. Standards: ASTM C1277 and ASTM C1540.

2. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
3. Extra Heavy duty couplings (80 in./lbs) shall be ASTM C1540 with shield thickness 0.015" or greater: Anaco/Husky SD-4000 or Clamp-All Hi-Torq 125.

## 2.5 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:
1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot ends unless flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern
3. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
4. Asphaltic Coating: ANSI/AWWA C151/A21.51, ANSI/AWWA C110/A21.10
5. Cement Lining: ANSI/AWWA C104/A21.4

B. Restrained joints:
1. Joints shall be restrained with EBBA Megalug, Romac Industries Romagrip, or approved equivalent. Thrust blocks or other restrains are not acceptable.

## 2.6 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe, Plain Ends: ASTM A312/A312M plain ends, seamless; stainless steel of types and schedules as indicated in Part 3 "Piping Applications" Article.

## 2.7 HIGH DENSITY POLYETHYLENE

A. Material used for the manufacture of high density polyethylene pipe and fittings shall be categorized as extra high molecular weight and meet all requirements of ASTM D33350. The high density polyethylene material shall be a cell class of PE345464C per ASTM D3350 and shall be assigned a Plastics Pipe Institute (PPI) recommended designation of PE4710. Pipe manufacturer shall be a member in good standing of the Plastic Pipe Institute.

B. Pipe and fittings shall be manufactured from material meeting the requirements of .41. The manufacturer shall certify that samples of the manufacturer's production product have been tested in-house in accordance with ASTM D2837, and validated in accordance with the latest revision of PPI TR-3.

C. Manufacturer shall comply with AWWA Standard C901 (1/2" through 3") and C906 (4" through 63"). The manufacturer shall comply with NSF Standard 61 and/or Standard 14 and must be certified by the NSF International for potable water. The material shall be listed by the Plastics Pipe Institute (PPI) a division of The Society of the Plastics Industry in PPI TR-4. The pipe material shall have a Hydrostatic Design Basis of 1600 psi at 73.4°F and 800 psi at 140°F. The PPI listing shall be in the name of the pipe manufacturer and testing and validation of samples of the pipe manufacturer's product shall be based upon ASTM D2837 and PPI TR-3.

D. Referenced Standards: AWWA, C-901, AWWA C-906, ASTM D2683, ASTM D3261, ASTM D3350, PPI TR-3, PPI TR-4 and NSF Standard 61.

E. Both pipe and fittings shall carry the same pressure rating. All fittings shall be pressure rated to match the system piping to which they are joined. AT the point of fusion, the outside diameter and minimum wall thickness of the fitting shall meet the outside diameter and minimum wall thickness specifications of ASTM F714 for the same size of pipe. All fittings shall be properly derated according to manufacturer’s written recommendations, and clearly labeled on the fitting as such. Manufacturer shall have a written specification for all standard fittings which establishes Quality Control criteria and tolerances. The manufacturer of the pipe shall be the same manufacturer of the fabricated fittings and other fabrications. The manufacturer shall certify that the materials used to manufacture pipe and fittings meet the requirements of this specification.

F. The pipe shall have product traceability. This shall be accomplished by the inclusion of a product code into the printline of all products. This shall notate the manufacturer, the date of manufacture, the lot and supplier of raw material, the location of manufacturer, and the production shift on which the product was produced.

G. Pipe and fittings shall be butt fusible according to the manufacturer recommended procedures. The socket or sidewall fittings shall also be to manufacturer’s recommended procedures. Pipe and fittings may also be joined with flanged adapters and convoluted ductile iron rings. Mechanical fittings acceptable for use with polyethylene pipe shall follow the recommendations of the mechanical fittings manufacturer.

H. Testing shall be in accordance with the procedure in the Plastics Pipe Institute (PPI) Technical Report TR-3.

I. The pipe and fittings shall be PE4710 as manufactured by Isco Industries, JE Eagle, Performance Pipe or approved equivalent.

## 2.8 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 Flanges:
   1. Source Limitations: Obtain dielectric flanges from single manufacturer.
   2. Description:
      a. Standard: ASSE 1079.
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: Per "Piping Applications" schedules.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Insulating Kits:
   1. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.
   2. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Gasket: Non-conductive
      c. Bolt Sleeves: Phenolic or polyethylene.

d. Washers: Phenolic with steel backing washers.

D. Dielectric Nipples:
1. Source Limitations: Obtain dielectric nipples from single manufacturer.
2. Description:
a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F1545.
c. Pressure Rating: Minimum 300 psig at 225 deg F.
d. End Connections: Male threaded or grooved where allowed in respective "Piping Applications" schedules.
e. Lining: Inert and noncorrosive, propylene.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATION

A. Refer to Div 22 and Div 23 Pipe Application Schedules for service, pipe size range, joining methods per system application.

### 3.2 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are 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. 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. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4" ball valve, with hose end and cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce horizontal pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 20 10 20 "Valves and Strainers".

Q. Install air vents and pressure-relief valves in accordance with Sections 22 and 23.

R. Install unions, flanges, or couplings in piping at final connections of equipment, and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 20 "Common Work Results for HVAC" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 20 10 70 "Identification" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 20 10 40 "Sleeves and Seals."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 20 10 40 "Sleeves and Seals."

## 3.3 JOINT CONSTRUCTION - GENERAL

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. For specialty systems and join according to pipe manufacturer's written instructions.

## 3.4 JOINT CONSTRUCTION - THREADED

A. Threaded Joints: Thread pipe with tapered pipe threads in accordance with 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.

## 3.5 JOINT CONSTRUCTION – WELDED

A. Welded joints shall be “V” type butt welds in accordance with ANSI B31.1.

B. The Contractor shall only use welders regularly engaged in the piping trades and certified by the National Certified Welding Bureau, using procedures set forth in ASME Boiler Construction Code, Section IX, “Welding Qualifications”.

C. Contractor shall keep a copy of welder's certification on file at Contractor's office. Upon request the Architect/Engineer may request Contractor to produce certifications. Any pipe installed by a non-certified welder shall be removed if requested by Architect/Engineer.

D. All steel piping shall be cleaned of mill scale and rust before assembly. Welds shall be chipped and hammered after each pass and joints shall be built up to at least the same thickness as that of the pipe wall. All welding shall be done in accordance with the welding procedures of the National Certified Pipe Welding Bureau conforming to the requirements of the ASA Code for Pressure Piping.

E. Architect/Engineer shall have the authority to accept or reject the welds and require random samples of installed welds to be removed, tested and inspected.

## 3.6 JOINT CONSTRUCTION – GROOVED

A. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

B. Gaskets shall be suitable for the temperature, pressure and compatibility with the fluid contained therein. Unless specifically specified otherwise or incompatibility with the system, gaskets shall be EPDM grade E.

C. Grooved couplings shall be ASTM-A47 grooved malleable iron clamp type couplings as manufactured by Victaulic or equivalent.

D. Grooved couplings for vibration isolation or as unions at equipment connections shall be similar to Victaulic Style 177; all others shall be similar to Victaulic Style 107.

## 3.7 JOINT CONSTRUCTION – SOLDERED

A. Joints for copper hydronic systems, domestic water, temperature controls, DWV systems and other applications of fluids below 250 degrees F. shall be soldered with 95-5 Tin Antimony. 50-50 Tin Lead solder shall not be used.

B. Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

C. Copper tubing shall be square-end cut by varied methods at the Contractor's option. The ends of the tubing shall be reamed to remove both internal and external burrs.

## 3.8 JOINT CONSTRUCTION – BRAZED

A. Joints in copper piping for gases, refrigerant lines, and other applications operating above 250 degrees F., or where otherwise specified shall be brazed.

B. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

## 3.9 JOINT CONSTRUCTION – FLANGED

A. Flanges shall be flat faced or raised faced as required for mating flanges of valves, specialties, equipment connections, etc.

B. Carbon steel hex head machine bolts, ASTM A307, grade 2, with heavy hex nuts shall be used for joining 125 and 150# flanged joints, unless otherwise specified.

C. Alloy steel machine bolts, studs and heavy hex nuts shall be used for joining of 250 and 300# flanged joints, unless otherwise specifi¬ed.

D. Lubricate the threads of bolts and studs with an acceptable commercial product. Include data with submittal for approval for piping material.

E. Gaskets shall be 1/16” thick non-metallic type conforming to ANSI B16.21 and shall be suitable for the pressure and temperature of the fluid contained therein, shall be provided at all flange joints. Full-faced gaskets shall be used for flat face flanges; ring gaskets shall be used for raised face flanges.

## 3.10 JOINT CONSTRUCTION – CAST-IRON SOIL PIPE

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.

C. Hubless, Cast-Iron Soil Piping Coupled Joints:

D. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

## 3.11 JOINT CONSTRUCTION – PE/HDPE

A. Joints for welding in polypropylene piping shall be made in accordance with the manufacturer's instructions, by a certified contractor.

B. No person may make a joint in a plastic pipe unless that person has been qualified. Qualifications shall be in accordance with Section 6(H) of the MPSC 4CSR240-40.030 Pipeline Safety Regulations and the Manufacturers Qualification Procedure.

3.12 JOINT CONSTRUCTION – AWWA MECHANICAL JOINTS

A. Mechanical joints and joining material shall meet the requirements of ANSI/AWWA C111/A21.11.

B. Clean bell and plain end, and lubricate gasket as recommended by manufacturer. The joint area must be free of dirt.

C. All bolts and tie rods shall be galvanized. Tighten bolt to 75-90 ft.-lbs. torque alternating from top to bottom maintaining equal distance between face and gland during tightening.

D. Where flanged joints are used to interface with equipment or other piping materials they shall be flanged joints in accordance with ANSI B16.1. The gaskets shall be full forced, made of rubber and shall meet the requirements of ANSI B16.21.

END OF SECTION 20 10 10

## SECTION 20 10 20 – VALVES AND STRAINERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Ball valves
   2. Butterfly valves
   3. Balancing valves
   4. Check valves
   5. Gate valves
   6. Globe valves
   7. Wye strainers
   8. Basket strainers

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

1.5 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene-propylene-diene monomer.

C. FKM: Fluoroelastomer.

D. NBR: Nitrile butadiene rubber (also known as "Buna-N").

E. NRS: Nonrising stem.

F. OS&Y: Outside screw and yoke.

G. PTFE: Polytetrafluoroethylene.

H. RPTFE: Reinforced polytetrafluoroethylene.

I. RS: Rising stem.

J. SWP: Steam working pressure.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
   3. Set ball valves open to minimize exposure of functional surfaces.
   4. Set butterfly valves closed or slightly open.
   5. Block check valves in either closed or open position.
   6. Set gate valves closed to prevent rattling.
   7. Set plug valves to 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 or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

# PART 2 - PRODUCTS

## 2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

A. It is indented that valves specifications are for high quality HVAC / Plumbing applications, not lesser quality “Contractor / Value / Economy” series. Valves produced internationally shall be from the Manufacturer’s owned facilities. Valves shall not be manufactured by third party OEM suppliers. Valve submittal shall indicate where the valve is assembled and tested.

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 B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

5. ASME B16.18 for cast-copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
7. ASME B16.34 for flanged- and threaded-end connections.
8. ASME B16.51 for press joint connections.
9. ASME B31.1 for power piping valves.
10. ASME B31.9 for building services piping valves.
11. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Bypass and Drain Connections: MSS SP-45.

G. Wrench: Furnish Owner with one wrench for every five (5) plug valves, for each size square plug-valve head.

H. Valve Actuator Type:
1. Hand Lever: For quarter-turn valves smaller than NPS 6” and smaller.
2. Gear Actuator: For quarter-turn valves NPS 8” and larger.
3. Where valves are located above 10'-0” AFF provide gear operator with chain wheel and guide. Provide chain hoods where required, to prevent fouling of chains on equipment and to clear walkways. Terminate chains approximately 6'-3” above the floor.

I. Valves in Insulated Piping
1. Provide 2-inch (50-mm) extended neck stems.
2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation. Ball valves T-handle: Nibco Nib-Seal, Apollo ThermaSeal, Hammond Valve Insulator/MS.
3. Provide memory stops that are fully adjustable after insulation is applied.

J. Only general valve series are specified. Valves shall have all options, trim, seat material, and accessories as specified whether or not listed as a prefix, suffix or valve number.

2.3 BALL VALVES

A. Ball Valves, Threaded Ends, 2.5” and smaller – Bronze, Two Piece with Full Port and Stainless Steel Trim:
1. Standard: MSS SP-110.
2. SWP Rating: 150 psig (1035 kPa).
3. CWP Rating: 600 psig (4140 kPa).
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded.
7. Seats: PTFE.

8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.
11. Manufacturer and models: Apollo 77-14X-01, Watts Series B-6080, or approved equal from Nibco or Hammond.

## 2.4 BUTTERFLY VALVES

A. Butterfly Valves, Single Flange (Lug Type) – Ductile Iron, with Aluminum-Bronze Disc:
   1. Standard: MSS SP-67, Type I, API-609, Type A
   2. CWP Rating: 200 psig 12” and smaller, 150 psig 14” and larger
   3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange. Integrally cast top plate for direct flush mounting of manual or power actuators without the use of brackets or adapters.
   4. Body Material: ASTM A536, ductile iron.
   5. Seat & Stem seals: Peroxide cured EPDM molded-in seat liner
      a. Valves shall be chemically compatible with: up to 4ppm of Chloramines ($NH_2Cl$, $NHCl_2$, $NCl_3$) 40°F-200°F, propylene glycol 0°F-200°F; and NSF-61 rated 40°F-180°F.
      b. Where used in potable water valve shall be “lead free” per 2011 Reduction of Lead in Drinking Water Act.
   6. Stem: One- or two-piece stainless steel.
   7. Disc: Aluminum bronze.
   8. Manufacturer and models: NIBCO figure LD 2000, Milwaukee ML-133E, Hammond 6411, Bray 31H, Apollo LD-145, Watts DBF-03, or approved equivalent. The following valves are NOT equivalent NIBCO N200, Milwaukee CL series, Hammond 5000 series, Apollo LC series, Watts BF series, or Crane 200 series.

## 2.5 BALANCE VALVES

A. Balance valves shall provide positive shut-off for service and shall have adjustable memory stops to allow returning to original balanced position after servicing.

B. Balance Valves, Threaded Ends, 3” and smaller:
   1. Design: Valves shall be multi-turn, fixed orifice, provide positive shut off, position indication, memory stops, integral pressure tap ports provided with “drip caps”. Quarter turn valves are not acceptable.
   2. CWP Rating: 300 psig.
   3. Body Material: ASTM B62, bronze, or dezincification resistant brass
   4. Ends: Threaded.
   5. Stem: Bronze.
   6. Disc: PTFE.
   7. Packing: Asbestos free.
   8. Handwheel: Polymer.
   9. Manufacturer and models: Nibco 1810, Tour and Anderson 786/787, Apollo 59A, Armstrong CBV, Macon Balancing STV/L Series or approved equivalent.

C. Balance Valves, Flanged Ends, 4”-12” - Iron, Class 150:

1. Design: Valves shall be multi-turn, fixed orifice, provide positive shut off, position indication, memory stops, integral pressure tap ports provided with "drip caps". Quarter turn valves are not acceptable.
2. CWP Rating: 200 psig.
3. Body Material: ASTM A536, ductile iron.
4. Ends: Threaded or soldered.
5. Stem: Bronze.
6. Disc: PTFE.
7. Packing: Asbestos free.
8. Handwheel: Polymer.
9. Manufacturer and models: Nibco F739, Tour & Anderson 788, Apollo 58A, Armstrong CBV, Macon Balancing STV, Watts CSM-91, or approved equivalent.

## 2.6 GATE VALVES

A. Gate Valves, Threaded or Soldered Ends - Bronze, RS, Class 125:
1. Standard: MSS SP-80, Type 2.
2. CWP Rating: 200 psig (1380 kPa).
3. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
4. Ends: Threaded or soldered. See pipe schedule articles.
5. Stem: Bronze.
6. Disc: Solid wedge; bronze.
7. Packing: Asbestos free.
8. Handwheel: Malleable iron
9. Manufacturer and models: Nibco 111, Grinnell 3010, Milwaukee 148, Hammond IB640, Watts 3100, Stockham B100, or approved equivalent.

B. Iron Gate Valves, OS&Y, Class 125:
1. Standard: MSS SP-70, Type I.
2. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
3. NPS 14 to NPS 24, CWP Rating: 150 psig.
4. Body Material: ASTM A126, gray iron with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Disc: Solid wedge.
8. Packing and Gasket: Asbestos free.
9. Handwheel: Cast iron
10. Manufacturer and models: Nibco F-617, Grinnell 6020, Milwaukee F-2885, Hammond IR1140, Watts F503, Stockham 6623, or approved equivalent.

C. Steel Gate Valves, OS&Y, Class 150:
1. Standard: API 600, ASME 16.34
2. NPS 2-1/2 to NPS 24, CWP Rating: 285 psig.
3. Body Material: ASTM A216 Gr WCB, cast carbon steel with bolted bonnet.
4. Ends: Flanged.
5. Trim: API trim 8.
6. Disc: Flexible wedge.
7. Packing and Gasket: Asbestos free.
8. Handwheel: Steel
9. Manufacturer and models: Powell Figure 1503, Hancock 600, or approved equivalent.

D. Epoxy Coated, Ductile Iron, Resilient Wedge, NRS, 300 CWP
1. Standard: AAWA C509
2. Listings: UL 262 listed, FM 1120/1130 approved, NSF 61
3. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
4. NPS 14 to NPS 48, CWP Rating: 250 psig.
5. Body Material: ASTM A536 ductile iron with bolted bonnet.
6. Coating: Epoxy exceeding ANSI/AWWA C550
7. Ends: Per Pipe schedule
8. Trim: Bronze
9. Disc: ASTM A536 ductile iron with peroxide cured EDPM
10. Packing and Gasket: Asbestos free.
11. Performance: Valves shall be "lead free" per 2011 Reduction of Lead in Drinking Water Act. Valves shall be chemically compatible with: up to 4ppm of Chloramines (NH2Cl, NHCl2, NCl3) 40°F-160°F and NSF-61 rated 40°F-160°F.
12. Manufacturer and models: Nibco F-619-RW, Mueller A-2362 thru 12 NPS, Mueller A-2361 14-48 NPS, or approved equivalent

## 2.7 CHECK VALVES

A. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 125:
1. Standard: MSS SP-80, Type 3.
2. CWP Rating: 200 psig.
3. Body Design: Horizontal flow, vertical up-flow
4. Body Material: ASTM B62, bronze.
5. Ends: Threaded.
6. Disc: Bronze.
7. Manufacturer and models: Nibco 413, Grinnell 3300, Watts 5000, Crane 1707, Hammond IB904, Stockham B320, or approved equivalent.

B. Check Valves, Swing Type, Flanged Ends - Iron, with Metal Seats, Class 125:
1. Standard: MSS SP-71, Type I.
2. CWP Rating, NPS 2-1/2 to NPS 12: 200 psig.
3. CWP Rating, NPS 14 to NPS 24: 150 psig.
4. Body Design: Clear or full waterway.
5. Body Material: ASTM A126, gray iron with bolted bonnet.
6. Ends: Flanged.
7. Trim: Bronze.
8. Gasket: Asbestos free.
9. Manufacturer and models: Nibco 918, Grinnell 6300A, Watts 511, Crane 373, Hammond IR1124, Jenkins 624C, Stockham G931, or approved equivalent.

C. Silent Check Valves, Center Guided - Iron, Globe, with Metal Seat, Class 125:
1. Standard: MSS SP-125.
2. CWP Rating, NPS 2-1/2 to NPS 12: 200 psig.
3. CWP Rating, NPS 14 to NPS 24: 150 psig.
4. Body Material: ASTM A126, gray iron.
5. Style: Globe, spring loaded.
6. Ends: Flanged.
7. Seat: Bronze.

8. Manufacturer and models: Nibco F-910, Grinnell Series 500, Milwaukee 125 Class, Mueller 91-AP, or approved equivalent.

## 2.8 WYE STRAINER

A. Bronze Y-Pattern Strainers, class 125
   1. Body: ASTM C87850 Lead free Bronze with threaded cover and bottom drain connection.
   2. CWP Rating: 200 psig.
   3. End Connections: Threaded ends for NPS 3 and smaller
   4. Strainer Screen: Stainless steel, mesh strainer, or perforated stainless steel basket.
      a. Water: 20 mesh
      b. Steam: 30 mesh
   5. Manufacturer and models: Mueller 351M, Keckley F-150, Watts 777/777S, Nibco T-221/222-A, Armstrong F4SC, Spirax/Sarco BT, or approved equivalent.

B. Cast iron Y-Pattern Strainers, class 125
   1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
   2. CWP Rating, NPS 1/2 to NPS 12: 200 psig.
   3. CWP Rating, NPS 14 to NPS 24: 150 psig.
   4. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   5. Strainer Screen: Stainless steel, mesh strainer, or perforated stainless steel basket.
      a. Water: 1/8 inch
      b. Steam: 3/64 inch
   6. Manufacturer and models: Mueller 751, Keckley A, Watts 77F-D, Nibco T-751-A / F-721-A, Armstrong A-FL-125, Spirax/Sarco F-125, Watts 77F-D, or approved equivalent.

# 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.

## 3.2 VALVE APPLICATION

A. Refer to Div 22 and Div 23 Pipe Application Schedules for valves types, size ranges, material, and end connection per system application.

B. Gauge cocks where not specified or specifically identified shall be ¼" bronze 2 piece body ball valves with lever handle and threaded ends per the above specification.

C. Drain valves and air vents shall be ¾" bronze 2 piece body ball valves per the above specification, with ¾" hose end adapter cap and chain. In ½" through 2" pipe, contractor may use Webstone model T-drain.

## 3.3 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. For valves in horizontal piping, install valves with stem at or above center of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and actuator or manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install check valves for proper direction of flow and as follows:
1. Check Valves: Center-guided type in horizontal or vertical position, between flanges.
2. Check Valves, Swing Type: In horizontal position with hinge pin level.
3. Check Valves, Lift Type: With stem upright and plumb.

I. Valve Tags: Comply with requirements for valve tags and schedules in Section 20 10 70 "Identification."

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

## 3.4 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.

END OF SECTION 20 10 20

# SECTION 20 10 30 – HANGERS, SHIELDS, SUPPORTS AND ANCHORS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems (Unistrut).
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment stands.
   8. Equipment supports.

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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. Equipment supports.
   2. Pipe Racks.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Seismic per Section 20 05 48 Vibration and Seismic Controls.

### 2.2 MANUFACTURERS

A. Acceptable manufacturers of hanger products that comply with the specifications.
   1. Anvil (ASC Engineered Solution)
   2. Eaton B-Line Systems

3. Tolco
4. PHD Manufacturing
5. National Pipe Hanger Corp

## 2.3 FASTENER SYSTEMS

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

B. Beam Clamps and devices used to attach to structure:

## 2.4 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, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.

B. Stainless Steel Pipe Hangers and Supports:
1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

C. Copper Pipe and Tube Hangers:
1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.

## 2.5 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, 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.

## 2.6 MANUFACTURED METAL FRAMING SYSTEMS (UNISTRUT)

A. MFMA Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel, stainless steel, Type 304, stainless steel, Type 316, extruded-aluminum channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Metallic Coating: Pregalvanized G90 (Z275), Electroplated zinc or Gold (yellow zinc dichromate) galvanized., Hot-dip galvanized.
7. Paint Coating: Green epoxy, acrylic, or urethane

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lbs.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. 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-58. 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 A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation: Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. 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.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. 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.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. 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.

M. Insulated Piping:
1. Use thermal-hanger shield insert with pipe hanger / clamp sized to match OD of insert.
2. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
3. Install MSS SP-58, Type 40, protective shields. Shields shall span an arc of 180 degrees.
4. 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.
5. 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.
    d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
    f. Pipes NPS 8 and Larger: Include insulation inserts per Section 20 20 25 “Insulation” of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place 1” minimum grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

## 3.4 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.

## 3.5 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. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

## 3.6 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 maximum.

## 3.7 HANGER AND SUPPORT SCHEDULE

A. Specialty hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

E. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

F. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

G. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

H. Use padded hangers for un-insulated piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Singular, horizontal, suspended piping above grade shall be hung with pipe hangers sized for the outside diameter of the insulation per the following schedule, unless noted otherwise:
   1. Systems without anchors and guides for expansion control
      a. NPS 3 inch and smaller: Adjustable ring, Figure 69
      b. NPS 4 inch and larger: Adjustable clevis, Figure 260
   2. Systems with anchors and guides for expansion control

a. All sizes: Adjustable steel yoke Figure 182 with protection saddle Figure 160 thru 165.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel piping: Figure 261
2. Copper piping: Figure CT-261

L. Finish shall per location and environment.
1. Indoor, dry, non-corrosive: Cadmium or zinc electro-plated
2. Indoor, wet or damp: Hot dipped galvanized
3. Outdoor: Hot dipped galvanized

END OF SECTION 20 10 30

# SECTION 20 10 40 – SLEEVES AND SEALS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Sleeves without waterstop.
   2. Sleeves with waterstop.
   3. Modular link-seal systems.
   4. Grout.
   5. Silicone sealants.
   6. Escutcheons.
   7. Penetration firestop

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sleeve Schedule

C. Penetration firestop Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

B. Field quality-control reports.

## PART 2 - PRODUCTS

### 2.1 SLEEVES WITHOUT WATERSTOP

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.

C. Steel Sheet Sleeves: ASTM A653/A653M, 0.0239-inch minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

## 2.2 SLEEVES WITH WATERSTOP

A. Molded HDPE with integral waterstop, furnish with nailer end caps.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, 2” steel collar, welded on both sides,hot-dip galvanized, with plain ends.

## 2.3 MODULAR LINK-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Designed to form a hydrostatic seal of 20 psig minimum.
   2. Sealing Elements: Material as indicated below, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
      a. Normal, except noted below: EPDM-rubber
      b. Steam and other service temperatures between 200°F-450°F: High-temperature-silicone
      c. Non-metical piping: Low Durometer EPDM, Shore 40 ± 5
   3. Pressure Plates: Reinforced Nylon Polymer.
   4. Connecting Bolts and Nuts: Stainless steel, Type 316 of length required to secure pressure plates to sealing elements.

B. Sleeves and seals manufactured by Garlock-LINK-SEAL, Flexicraft Industries, Advance Products & Systems, Metraflex, or approved equivalent.

## 2.4 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000 psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

A. Silicone Sealant, S, P, T, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant. b. Standard: ASTM C920.

## 2.6 ESCUTCHEONS

A. Escutcheon Types:
   1. One-Piece, Stainless Steel Type: With polished stainless steel finish.
   2. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

## 2.7 PENETRATION FIRE STOP

A. Refer to Division 7 requirements.

B. All penetrations through rated assemblies, walls, shafts, floors, roofs, etc., shall be firestopped in accordance with Local Building Codes, NFPA, U.L. Fire Resistant Directory, and manufacturer's instructions.

C. Obtain penetration firestopping systems for each type of opening indicated from single manufacturer.

D. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.

E. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.

F. Penetrations in Smoke Barriers: Penetration firestopping systems with ratings determined in accordance with UL 1479.

G. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested in accordance with ASTM E84 or UL 72

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions for partition types and execute work per the requirements herein.

## 3.2 INSTALLATION OF SLEEVES AND CORE DRILLING - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes, except where noted. Prior to core drilling structure shall be scanned with X-ray, Redar, or other means to locate rebar and verify that conduit/pipes are not imbedded in the concrete, Submit scans with an overlay of the proposed core drills for approval.

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.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078400 "Penetration Firestopping."

## 3.3 INSTALLATION OF SLEEVES WITH WATER STOP

A. Install sleeve with water stop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

## 3.4 INSTALLATION OF LINK-SEAL SYSTEMS

A. Install link-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.

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.
   1. Locate the bolts in accessible position to allow tightening.

## 3.5 SLEEVE SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. New Exterior Concrete Walls below Grade:
      a. Link seal system. Molded HDPE sleeves with water stops.
   2. New Exterior Concrete Walls above Grade:
   3.
   4. Existing Exterior Concrete Walls below Grade:
      a. Link seal system. Core drilled hole
   5. Existing Exterior Concrete Walls above Grade:
      a.
   6. New Concrete Slabs-on-Grade:
      a. Sleeves with water stops.
         1) Select sleeve size to allow for 2-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   7. Existing Concrete Slabs-on-Grade:
      a. Sleeves with water stops.
         1) No Sleeve: Core drill to allow for 2-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   8. New Concrete Slabs above Grade:
      a. Mechanical rooms and wet areas: Sleeves with water stops
      b. Dry areas: Molded Sleeve
   9. Existing Concrete Slabs above Grade:
      a. Mechanical rooms and wet areas: Sleeves with water stops
      b. Dry areas: Core Drill
   10. Interior Partitions:
      a. Masonry: Sheet steel
      b. Drywall: neatly field cut round holes with hole saws

## 3.6 INSTALLATION OF ESCUTCHEONS

A. Install escutcheons for piping penetrations of finished 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.

C. Use one-piece escutcheons for all sizes available on new piping. Use spit type on existing piping and large piping where one-piece not available.

## 3.7 INSTALLATION OF PENETRATION FIRESTOP

A. Install penetration firestopping systems in accordance with manufacturer's written installation instructions and published drawings for products and applications.

B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
   1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

C. Install fill materials by proven techniques to produce the following results:
   1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items to achieve required fire-resistance ratings.
   2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
   3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

## 3.8 INSTALLATION OF DRAFTSTOP

A. All penetrations through non-rated walls, floors, etc., shall be sealed for draft stopping with sealant, grout, etc., designed for this use.

B. Accommodate movement, such as pipe vibration, water hammer, thermal expansion, and other normal building movement without damage.

END OF SECTION 20 10 40

## SECTION 20 10 50 – BASIC MECHANICAL METHODS - RELATED WORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Demolition
   2. Cutting and Patching
   3. Excavation, Trenching, and Backfilling
   4. Concrete Work
   5. Painting
   6. Lubrication
   7. Draining, Filling, and Venting Systems

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 SHOP DRAWINGS

A. Detailed and dimensioned drawings of size, location, reinforcing and hardware contained therein of concrete work to be provided.

1.4 INFORMATIONAL SUBMITTALS

A. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include: name, license number, and address of technician; date refrigerant was recovered; the machine and serial number of the reclaim equipment used, type and quantity of reclaimed refrigerant, and all other required data.

1.5 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.

## PART 2 - PRODUCTS (not applicable)

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Refrigerant: Before starting demolition, remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction.

### 3.2 DEMOLITION

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
   1. Coordinate with Owner for shut off of private utility of indicated services/systems.
   2. Arrange to shut off public utilities with utility companies.
   3. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.
      a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
      b. Equipment to Be Removed: Disconnect and cap services and remove equipment.
      c. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
      d. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
      e. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Where indicated on the drawings to abandon in place.
      a. Piping to Be Abandoned in Place: Drain piping, disconnect at the points indicated, and cap or plug piping with same or compatible piping material and leave in place.
      b. Ducts to Be Abandoned in Place: Disconnect at the points indicated, cap or plug ducts with same or compatible ductwork material and leave in place.
      c. Underground Piping to Be Abandoned in Place: Drain piping, disconnect at the points indicated, and fill abandoned piping with hydraulic cement.
   5. Dead legs of branch piping are not permitted unless a cap is specifically shown on the drawings. Where a cap is not shown and the drawings indicate to cap piping, the Contractor shall remove branch piping back to the main and cap at that point.

### 3.3 CUTTING AND PATCHING

A. The basic premise of this Sub-section is that the cutting and patching (where required) are performed in existing building components. In “new” construction, the premise is that the building component is already in place.

B. The Contractor requiring the penetration of or the access way in the building structure to fulfill the intent of the Project Documents for his Work shall be responsible for the cutting and the subsequent patching in accordance with the following criteria:
   1. No structural component of the building shall be cut or violated without express approval of the Architect/Engineer.
   2. The Contractor shall verify the presence of any concealed utility or service within the structure (walls, roof, floor, etc.) in question, and shall be responsible for maintaining continuity and/or replacing it.

C. Cutting of work-in-place in “new” construction because of error, neglect or damage inflicted shall be the responsibility of the Contractor precipitating the issue.

D. “Patching” shall be construed as the repairing or replacing of the building structure to return it to an original or new condition, in the opinion of the Owner and/or Architect/Engineer, as existed prior to the cutting.

E. Patching and finishing work shall be the responsibility of the Contractor requiring the cutting. The patching shall match all the substantive and visual aspects of the structure and adjacent surfaces. Restoration and finishes shall be as specified and executed in the respective sections, schedules and/or details of the Project Documents for the general construction work. Completed work and any special requirements shall be subject to approval by and satisfaction of the Architect/Engineer.

3.4 DRAINING, FILLING AND VENTING SYSTEMS

A. The Contractor shall provide all required labor for draining, filling and venting of new or modified systems as many times as required during construction and for all phasing activities**.**

B. Where draining and filling systems affects other systems or the Owner’s normal operations, then they shall be scheduled at least 24 hours in advance with the Owner and shall be carried out to minimize such disruptions.

3.5 LUBRICATION

A. Provide all oil and grease for the operation of all equipment until acceptance. The Mechanical Contractor and Subcontractors shall be held responsible for all damage to bearing while the equipment is being operated by them up to the date of acceptance of the equipment. Protect all bearings during installation and thoroughly grease steel shafts and other unpainted steel surfaces to prevent corrosion. All motors and other equipment shall be provided with covers as required for proper protection during construction. For equipment that is received void (dry) of lubrication the Contractor shall lubricate the equipment before storing to prevent internal damage to the equipment.

B. After the Contractor moves on site, they shall hand rotate all existing rotating equipment at least once every week in order to make sure the equipment remains free and eliminate the risk of including a permanent set in the rotating shaft or bearing.

3.6 CONCRETE WORK (CAST-IN-PLACE)

A. General:
   1. This sub-section shall supplement Section 03300 – Concrete Work for the concrete work required to install the work of Divisions 20 - 25.
   2. In the event of a conflict between this sub-section and Section 03300, the more stringent shall apply.

B. Provide concrete foundations, bases and/or housekeeping pads for mechanical equipment furnished in his respective scope of work where such are not indicated on the architectural or structural drawings. Concrete work shall include requisite excavation, formwork, reinforcing and contained hardware.

C. Housekeeping Pads:
   1. All equipment setting on concrete or other type of pave flooring shall be set upon a raised “housekeeping” pad, unless noted otherwise.
   2. The Contractor shall be responsible for this size, location, and any required anchor bolts. In general, housekeeping pads shall be a minimum of 3 ½” high, a ¾” chamfer on exposed corners and edges, and a minimum of 3” beyond the equipment on all sides or as required for anchor bolt edge distance.
   3. Housekeeping pads shall be 3000 psi 28-day compressive strength concrete. Pads shall be reinforced and doweled to the floor slab. Refer to ASHRAE-A Practical Guide to Seismic Restraint 1999, Chapter 6 – Housekeeping Pads for size and spacing of reinforcing and dowels.

D. Thrust Blocks:
   1. Thrust blocks shall be installed at all changes in direction and end points in unrestrained underground pressure piping systems and where required by installation standards, or manufactures instructions.
   2. Thrust blocks shall only contact the backside of the fittings and shall not cover any joints. All thrust blocks will be inspected by the Owner’s Representative prior to backfilling, provide a minimum of 3 days’ notice.

3.7 ACCESS DOOR INSTALLATION

A. Access to mechanical equipment and ductwork of Divisions 20 - 29 required for testing, adjusting, inspection, maintenance or servicing shall be the responsibility of the Contractor. Doors for manufactured equipment shall be an integral feature included with the respective equipment. Access openings in ductwork shall be included with the fabrication in accordance with SMACNA practices.

B. Openings in building components for access to concealed mechanical work shall be furnished by the Contractor and installed with the building construction work. Access doors shall be located as indicated on the Plans or as strategically required for inspection, maintenance, and service. The model and style shall fit the building construction, fire rating requirements and provide adequate size and function.

C. Access doors shall be sized as shown on the drawings or shall be a minimum size of 18” x 18” and otherwise shall be large enough for purpose intended and shall be fabricated of heavy gauge steel frames and door panels with double action concealed spring hinges, 1/4 turn flush screwdriver operated cam locks and prime coat paint finish. Access doors for various applications shall be as follows:

| | Building construction: | Milcor access door Style: |
|---|---|---|
| 1. | flush door in dry wall construction (walls and ceilings) | DW |
| 2. | flush door in masonry or tile walls with exposed frame flange | M (steel), MS (stainless) |
| 3. | flush door in plaster construction (walls and ceilings) | K |
| 4. | recessed door in acoustical plaster ceiling | AP |
| 5. | recessed door in suspended drywall ceiling | CT (aluminum - wet locations) |
| 6. | flush door in suspended drywall ceiling | CF (aluminum – wet locations) |
| 7. | door in suspended drywall ceiling | ATR (fire resistive door) |
| 8. | fire rated separation (walls and ceilings) - fire rated door | |

D. Access doors are not required for Work above lay-in panel ceilings.

END OF SECTION 20 10 50

# SECTION 20 10 60 – TESTING, ADJUSTING AND BALANCING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Testing, Adjusting, and Balancing of Air Systems:
   2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
   3. Testing, Adjusting, and Balancing of Domestic Water Systems:
   4. Testing, adjusting, and balancing of steam and condensate piping systems.
   5. Testing, adjusting, and balancing of equipment. <u>Includes the dust collection system.</u>
   6. Testing, adjusting, and balancing of existing HVAC systems and equipment prior to modification.
   7. Procedures for exhaust hoods.
   8. Sound tests.
   9. Duct leakage tests verification.
   10. Pipe leakage tests verification.
   11. HVAC-control system verification.

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

### 1.3 REFERENCES

A. National Standards for Total System Balance, by the Associated Air Balance Council (AABC), latest edition.

B. Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems, by the National Environmental Balancing Bureau (NEBB), latest edition.

C. 2019 Application Handbook, Chapter 39, Testing, Adjusting and Balancing by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

## 1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference on site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
   1. Minimum Agenda Items:
      a. Coordinate requirements in subparagraphs below with Section 013100 "Project Management and Coordination."
      b. The Contract Documents examination report.
      c. The TAB plan.
      d. Needs for coordination and cooperation of trades and subcontractors.
      e. Proposed procedures for documentation and communication flow.

## 1.5 ACTION SUBMITTALS

A. “Pencil copy” of TAB report.

B. Certified TAB reports.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation:
   1. Name and address of the proposed Balancing Contractor and that the TAB specialist and this Project's TAB team members meet the qualifications specified.
   2. Name of the Mechanical Contractor's representative responsible for the balancing work.

B. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Within 60 days Contractor's Notice to Proceed, submit the name of Balancing Contractor's representative for coordination with the Mechanical Contractor.

D. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures.

E. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists.

F. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

G. Sample report forms.

H. Instrument calibration reports, to include the following:
   1. Instrument type and make.

a. Serial number.
b. Application.
c. Dates of use.
d. Dates of calibration.

1.7 QUALITY ASSURANCE

A. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

B. Work shall be conducted under the supervision of an individual certified by NEBB, or AABC, or TABB by trained technicians. All test results shall be documented per the previously approved procedure and transmitted to the Architect/Engineer for review as a requisite for final acceptance and payment. Final inspection shall follow completion and acceptance of the test results.

C. The balancing contractor shall review plans and specifications for balancing dampers, balancing valves, gauge connections, airflow/pitot sections. The Contractor shall notify the Engineer if the Contractor cannot perform the Work because of inadequate provisions so that the inadequacy can be corrected by change order during project construction without any cost over and above the device itself. No excuses during the testing and balancing procedure will be accepted for Contractor's lack of performance, and the Contractor shall be responsible for the additional cost of adding the required device(s) into the completed systems.

D. Employment of a Balancing Subcontractor by the Contractor shall not relieve him of obligations to perform Work in accordance with the Project Documents.

1.8 FIELD CONDITIONS

A. **Partial Owner Occupancy**: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

## 3.2 RESPONSIBILITIES AND COORDINATION

A. Work by Contractor, which installed the respective system to be tested, shall include the following:

1. Schedule, coordinate and sequence the testing, adjusting and balancing of the respective systems. Prepare and distribute a schedule.
2. Verify that the respective equipment, ductwork, piping and temperature control systems have been provided, each is operable and apparently functioning all in accordance with and to the intent of the Project Documents. In particular, the following shall be checked and noted as having been accomplished prior to the testing, adjusting and balancing:
   a. Initial checkout and start-up of all equipment.
   b. Pressure and leak testing, and cleaning of all systems.
   c. Alignment and adjustment of motor drives, and lubrication of bearings.
   d. Air filters replaced.
   e. All dampers, manual line valves, control valves and balancing valves are in the “open” position.
3. Verify that all instruments, measuring devices, meters, immersion wells, taps, valves, specialties, dampers, measuring and sensing elements, access openings, etc. have been provided in correct quantities and locations to permit commencement of the testing, adjusting and balancing of the Work. Correct deficiencies and/or modify the Work, as required.
4. Provide the Balancing Contractor with all pertinent shop drawings on equipment to be tested, adjusted and balanced.
5. Provide the Balancing Contractor with a set of “as-built” drawings or the Mechanical Contractor's marked-up “record” set showing all changes to the mechanical systems.

B. Work by Balancing Contractor shall include the following:
1. Perform a total system balance in accordance with NEBB, or AABC, or TAAB.
2. Direct measurement of temperatures, pressures, air and fluid quantitative flow rates and any other values necessary to establish the status of each system in comparison with the Project Documents.
3. Adjust components and devices to achieve design operating conditions within acceptable tolerances for each system. Do not use shut-off devices for balancing unless indexed. Lock memory stops or mark set points of balancing devices. Replace all system components removed temporarily during the testing and balancing effort, set all temperature controls properly and generally leave the systems in working order and “as-new” condition.
4. Report to the Architect/Engineer any existing installed or operating condition that deviates from the design or intent of the Project Documents, and that the Balancing Subcontractor believes to be beyond the scope of his work.
5. Furnish fixed sheaves to the Owner, upon acceptance of the balancing report, for fans furnished with adjustable sheaves where the balancing contractor was able to make the required speed adjustments with the factory sheave.
6. Furnish and install fixed sheaves for fans furnished with adjustable sheaves where a speed change, beyond that obtainable with the adjustable sheave, is required to obtain design airflow. The system shall be proportionally balanced, then the required fan speed shall be calculated based upon the fan laws. Contractor shall also calculate the required brake horsepower at the design airflow, if this exceeds the nameplate horsepower the Architect/Engineer shall be notified.
7. Furnish and install fixed sheaves for fans furnished with fixed sheaves where a speed change is required to obtain design airflow. The system shall be proportionally balanced,

then the required fan speed shall be calculated based upon the fan laws. Contractor shall also calculate the required brake horsepower at the design airflow, if this exceeds the nameplate horsepower the Architect/Engineer shall be notified.

## 3.3 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning in accordance with the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.4 PROCEDURES

A. The procedures listed herein are presented to enhance the procedures of the referenced agencies and the lack of a procedure being presented herein does not relieve the Contractor from following the procedures of the referenced agencies.

B. In general, balancing dampers shall not be used to adjust the cfm quantity of fans but rather only to adjust the proportion of the airflow within the system. The fan speed shall be adjusted, with all of the dampers open, to a cfm slightly greater than design cfm. Then the dampers shall be adjusted to move more air towards the end of the system. The balancing damper at the furthest points of the system should be nearly full open. If these furthest dampers are not open then the fan speed shall be reduced and the process repeated until a satisfactory result is achieved.

C. Prior to testing and adjusting VAV boxes the Balancing Contractor shall verify that the controllers are functioning properly and with the proper sequence of operation. If any inadequacies are encountered, they shall be reported for correction prior to testing and adjusting.

D. Pitot tube traverses shall be taken at all branch ducts serving more than three (3) VAV boxes, more than six (6) air devices, or more than 10% of the system total airflow, and at all places indicated on the plans. The static pressure shall be recorded at each pitot tube traverse.

E. VAV box airflow shall be measured by a pitot tube traverse in the inlet duct and measurement of the individual air device outlets, these measurements shall be used to calibrate the maximum and minimum airflows of the VAV box controller. The VAV box airflow measuring device shall not be used in the testing and balancing procedure for measuring air quantities.

F. Systems with diversity shall be tested in accordance to a method agreed upon by Engineer and is to be established when the Contractor submits his procedures to the Engineer for approval. Typically, this may be: to force the East zones to operate design capacity while west zones are left to operate at their given load; or that some air handling units would be forced to operate at design capacity while other units may be off or left to operate at their given load.

G. Systems with air economizer cycles shall be adjusted to provide near linear flow as the amount of outdoor varies. Three (3) conditions to be tested are minimum outdoor air, 50% outdoor air, and 100% outdoor air. Record the values of total supply, return, relief, and building differential pressure at each of these conditions. Systems with return fans shall have the return damper adjusted to provide a change from positive to negative gauge pressure to provide a negative mixed air plenum pressure.

H. When the Contractor has any questions regarding how the systems operate or cannot obtain design performance, they should contact the Engineer for clarifications or further instruction. The work shall not be considered complete until all systems and components achieve design performance unless the Engineer issues written direction otherwise.

I. All systems shall be adjusted between 10% above the design value as a maximum, to the design value as a minimum.

J. Domestic hot water recirculating system shall be adjusted to provide equal flow in each branch or as otherwise indicated on the drawings.

K. Domestic hot water heating system shall be adjusted to the heater/heat exchanger flow rate indicated on the drawings.

## 3.5 DUCTWORK LEAKAGE TESTING

A. Installed ductwork on systems greater than 5HP shall be tested prior to installation of access door, take-offs, or other specialties.

B. A testing shall be scheduled for witness per the general conditions.

C. The supply trunk duct for each system shall be tested in whole or up to 100' in length whichever is lesser.

D. The return trunk duct for each system shall be tested from 50' upstream of the fan inlet to the unit plenum box.

E. Exhaust ductwork for each fan shall be tested from 50' upstream of the fan inlet to the point of discharge.

F. Outdoor air and relief air ducts for each fan system shall be tested in whole.

G. Ductwork shall be tested as follows:
1. Ductwork shall be tested in accordance with SMACNA HVAC Air Duct Leakage Test Manual.
2. Use a certified orifice tube for measuring the leakage.
3. Define section of system to be tested and blank off.
4. Determine the design airflow for the portion of the duct to be tested.
5. Determine the allowable leakage (cfm) for the section being tested.
6. Pressurize to operating pressure and repair any significant or audible leaks.
7. Repressurize and measure leakage.
8. Repeat steps 6. and 7. until the leakage measured is less than the allowable defined in step 5.

H. The following Leak Class and Duct Pressure Class shall be used to determine the Leakage Factor in cfm/100 S.F. Duct. Ducts shall be tested at the design pressure class. Max. leakage = Leak Class x (design pressure) $^{0.65}$

| | Rectangular Duct Pressure Class | Leak Class |
|---|---|---|
| 1. | All | 6 |

(i.e. 4” duct systems shall be tested at 4” and the leakage shall not exceed 14.8 cfm/100 S.F. duct and 2” duct systems shall be tested at 2” and the leakage shall not exceed 9.4 cfm/100 S.F. duct)

| | Round Duct Pressure Class | Leak Class |
|---|---|---|
| 2. | All | 3 |

(i.e. 4” duct systems shall be tested at 4” and the leakage shall not exceed 7.4 cfm/100 S.F. duct and 2” duct systems shall be tested at 2” and the leakage shall not exceed 4.7 cfm/100 S.F. duct)

3.6 REPORTS

A. Reports shall be submitted in 9” x 12” binder complete with cover identification, index page, and indexing tabs. Reports shall not contain footnotes explaining why the system was not balanced to the required performance.

B. The form of the testing and the report shall be submitted and approved prior to testing work. Reports shall be submitted on pre-approved forms.

C. Diagrams, as required, to clarify locations of measurements and/or reading shall be included in the report.

D. Final acceptance and payment of the contract shall not be issued before final report is approved.

E. Air handling unit forms shall contain the following minimum information:
1. Unit Name.
2. Make/Model.
3. Type/Size.
4. Serial Number.
5. Fan Arrangement/Class/Rotation
6. Discharge Location.
7. Sheave Make and No.
8. Sheave Diameter and Bore.
9. No. Belts/Make/Size.
10. Motor Make/Frame.
11. Motor Horsepower.
12. Motor Volts/Phase/Amps.
13. Motor Full Load Amps/S.F.
14. Motor Sheave Make and No.
15. Motor Sheave Diameter and Bore.
16. Sheave Centerline Distance.
17. Design and Actual Supply CFM.
18. Design and Actual Total S.P.
19. Design and Actual Fan RPM.
20. Design and Actual Motor Volts (each phase).
21. Design and Actual Motor Amps (each phase).
22. Design and Actual Discharge S.P.
23. Design and Actual Suction S.P.
24. Design and Actual Pressure Drops Across Components.
25. Design and Actual Minimum Outside Air CFM.
26. Design and Actual Return Air CFM.
27. Coil Condition Wet/Dry.
28. Filter Condition Clean/Dirty.
29. Minimum Outside Air Damper Position (degrees 90° open; 0° closed)
30. Maximum Outside Air Damper Position (degrees 90° open; 0° closed)
31. Return Air Damper Position (degrees 90° open; 0° closed) for Positive Pressure on Upstream Side and Negative Pressure on Downstream Side

F. Terminal unit forms shall contain the following minimum information:
1. VAV Box No.
2. VAV Box Make/Size.
3. Room Number of Area(s) Served.
4. Design and Actual Maximum Cooling CFM.
5. Design and Actual Minimum Cooling CFM.
6. Design and Actual Minimum Heating CFM.
7. Minimum static pressure required at duct static pressure sensor to provide design CFM with box air valve fully open.
8. Flow Factor Variable for DDC Calibration
9. For Fan Powered Terminal Boxes:
10. Motor Horsepower.
11. Motor Volts/Phase/Amps.
12. Motor Full Load Amps/S.F.
13. Motor Speed H/M/L.
14. Filter Size and Quantity.

G. Air Outlet forms shall contain the following minimum information:
1. Area Served.
2. Grille Type.
3. Grille Size.
4. Design, Preliminary and Final CFM.
5. Damper Position (degrees 90° open - 0° closed).

H. Pump forms shall contain the following minimum information:
1. Pump No.
2. Service.
3. Make/Model.
4. Type/Size.
5. Serial Number.
6. Seal Type.
7. Design Impeller Size.
8. Required NPSH.
9. Motor Manufacturer/Frame Size.
10. Motor HP/RPM.
11. Volts/Phase/Amps.
12. Full Load Amps.S.F.
13. System Pressure (Pump off).
14. Shut-off Pressure.
15. Actual Impeller Size.
16. Design, Preliminary, and Final Flow.
17. Design, Preliminary, and Suction, Discharge, and Differential Pressure.
18. Design, Preliminary, and Voltage, each phase.
19. Design, Preliminary, and Amps, each phase.

I. Air handling unit coil forms shall contain the following minimum information:
1. System No.
2. Location.
3. Service (Preheat, Cooling, Reheat).
4. Coil Type.
5. No. Rows/Fins per inch.

6. Manufacturer.
7. Model No.
8. Face Area (Sq. Ft.).
9. Design and Actual Air Quantity.
10. Design and Actual Air Velocity.
11. Design and Actual Air Pressure Drop (in. w.c.).
12. Design and Actual Outside Air DB/WB.
13. Design and Actual Return Air DB/WB.
14. Design and Actual Entering Air DB/WB.
15. Design and Actual Leaving Air DB/WB.
16. Design and Actual Air ΔT.
17. Design and Actual Water Flow.
18. Design and Actual Water Pressure Drop (ft.).
19. Design and Actual Entering Water Temperature.
20. Design and Actual Leaving Water Temperature.
21. Design and Actual Water ΔT.
22. Design and Actual Inlet Steam Pressure.
23. Design and Actual Control Valve Pressure Drop.
24. Design and Actual Expansion Valve.
25. Design and Actual Refrigerant Suction Pressure.
26. Design and Actual Refrigerant Suction Temperature.

J. Exhaust, return/relief fan forms, including for the dust collection system, shall contain the following minimum information:
1. Unit Name.
2. Make/Model.
3. Type/Size.
4. Serial Number.
5. Fan Arrangement/Class/Rotation
6. Discharge Location.
7. Sheave Make and No.
8. Sheave Diameter and Bore.
9. No. Belts/Make/Size.
10. Motor Make/Frame.
11. Motor Horsepower.
12. Motor Volts/Phase/Amps.
13. Motor Full Load Amps/S.F.
14. Motor Sheave Make and No.
15. Motor Sheave Diameter and Bore.
16. Sheave Centerline Distance.
17. Design and Actual CFM.
18. Design and Actual Total S.P.
19. Design and Actual Fan RPM.
20. Design and Actual Motor Volts (each phase).
21. Design and Actual Motor Amps (each phase).
22. Design and Actual Discharge S.P.
23. Design and Actual Suction S.P.

K. Heat Exchanger forms shall contain the following minimum information:
1. Unit Name.
2. Service.

3. Rating (Btu/hr).
4. Circuiting.
5. Manufacturer.
6. Model Number.
7. Serial Number.
8. Design and Actual Steam Pressure.
9. Design and Actual Flow Rate (#/hr).
10. Primary Water Design and Actual Entering/Leaving Temperature.
11. Primary Water Design and Actual ΔT.
12. Primary Water Design and Actual Air Entering/Leaving Pressure.
13. Primary Water Design and Actual Water ΔP.
14. Primary Water Design and Actual Flow Rate (gpm).
15. Secondary Water Design and Actual Water Entering/Leaving Temperature.
16. Secondary Water Design and Actual Water ΔT.
17. Secondary Water Design and Actual Entering/Leaving Pressure.
18. Secondary Water Design and Actual Water ΔP.
19. Secondary Water Design and Actual Flow Rate (gpm).
20. Secondary Water Design and Actual Control Setpoint.

L. Terminal Unit or VAV Coil forms shall contain the following minimum information:
1. Room No./VAV Box No.
2. Size.
3. Design and Actual Air Flow Rate (CFM).
4. Design and Actual Water Flow Rate (gpm).
5. Design and Actual Entering Water Temperature (nominal).
6. Design and Actual Entering Air Temperature.
7. Design and Actual Leaving Air Temperature
8. Design and Actual Capacity (Btu/hr).

M. Water Heater Test forms shall contain the following information:
1. Unit Name.
2. Make/Model.
3. Serial Number.
4. Location.
5. Type/Size.
6. Fuel/Input.
7. Number of Passes.
8. Ignition Type.
9. Burner Control.
10. Volts/Phase/Hertz.
11. Design and Actual Operating Pressure and Temperature.
12. Design and Actual Entering and Leaving Temperature.
13. Design and Actual Number of Safety Valves/Size.
14. Design and Actual Safety Valve Setting.
15. Design and Actual High Limit Setting.
16. Design and Actual Operating Control Setting.
17. Design and Actual High Fire Setpoint.
18. Design and Actual Low Fire Setpoint.
19. Design and Actual Voltage (T1-T2, T1-T3, T2-T3).
20. Design and Actual Amperage (T1, T2, T3).
21. Design and Actual Draft Fan/Volts/Amps.

22. Design and Actual Manifold Pressure.
23. Design and Actual Output-MBH.
24. Design and Actual Safety Controls – Check.

END OF SECTION 20 10 60

# SECTION 20 10 70 – IDENTIFICATION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Equipment labels.
   2. Pipe labels.
   3. Duct labels.
   4. Valve tags.
   5. Warning signs and labels.
   6. Warning tape.
   7. Underground warning tape.

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION
   2. The materials specified herein Section 20 10 70 shall apply to Division 25 Temperature Control Systems. Additional identification work is specified in Division 25

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Submit an Identification Product Schedule consisting of the following minimum information:
   1. Material - type of identification product.
   2. System - indicate which system or equipment materials will be used for.
   3. Manufacturer - Manufacturer's name, product name and model numbers.
   4. Accessories - Miscellaneous materials used in affixing identification.

C. Submit a valve tag list for approval prior to ordering or making valve tags.

D. Submit legends, background color, letter color, lettering sizes for pipe markers, valve tags, and engraving wording for each equipment nameplates.

### 1.3 CLOSEOUT SUBMITTALS

A. Valve tag information is required on “as-built” drawing submittals.

B. List tagged valves in a valve schedule in the operating and maintenance manual.

PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Manufactures:
1. Seton Nameplate Corp.
2. Brady Signmark Division
3. Craftmark Identification Systems
4. D & G Sign and Label
5. Or approved equipment

## 2.2 PERFORMANCE REQUIREMENTS

A. Current and accepted edition of the following codes and standards shall apply to the Work of this section:
1. ANSI/ASME A 13.1 - "Scheme for the Identification of Piping Systems".
2. ANSI Z535.1 – "Standards for Safety Signs and Color"

## 2.3 EQUIPMENT LABELS

A. Plastic Labels for Indoor Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of 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 1 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 of 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.

B. Metal Labels for Outdoor Equipment:
1. Material and Thickness: stainless steel, 0.025 inch
2. Letter and Background Color: Black filled lettering on brushed stainless steel.
3. Minimum Label Size: Length and width vary for required label content, but not less than 3 by 1 inch.

C. Fasteners: Stainless steel rivets or self-tapping screws.

D. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules).
1. First line: Description (i.e. Exhaust Fan, Chilled Water Pump, etc.)
2. Second Line: Unit designation (i.e. EF-1)

## 2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
   1. Size letters in accordance with ASME A13.1 for piping. At least 1/2 inch and proportionately larger lettering for larger pipes.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to circumference of pipe and to attach to pipe without fasteners or adhesive.
   1. Integral flow arrow
   2. Up to 10 inch OD full circumference of pipe
   3. Greater than 10 inch OD, fastened with heavy duty nylon ties.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
   1. Flow direction shall be separately labeled with 2” wide pressure sensitive tape. The flow arrow band shall overlap the service label to secure it in place and shall not be less than two complete wraps around the pipe.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
   1. Flow-Direction Arrows: Include flow-direction arrows. Arrows may be either integral with label or applied separately.

## 2.5 DUCT LABELS

A. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Label Size:
   1. Ducts less than 12 inch: at least 8 by 2 inch with 3/4 inch lettering.
   2. Ducts greater than 12, less than 48 inch: at least 14 by 2-1/4 inch with 1-1/2 inch lettering.
   3. Ducts greater than 48 inch: at least 20 by 4 inch with 2-1/2 inch lettering.

## 2.6 VALVE TAGS

A. Description: Stamped or engraved with 1/4 letters for piping system abbreviation and 1/2-inch numbers that are black enamel filled.
   1. Tag Material: Brass, 1-1/2 inch diameter, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
   2. Fasteners: No. 6 brass bead chain or No. 16 brass jack chain

## 2.7 WARNING SIGNS AND LABEL

A. Material: Vinyl.

B. Minimum Thickness: 0.005 inch (0.12 mm).

C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

E. Maximum Temperature: 160 deg F (70 deg C).

## 2.8 WARNING TAPE

A. Material: Vinyl.

B. Minimum Thickness: 0.005 inch.

C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

E. Maximum Temperature: 160 deg F.

F. Minimum Width: 2 inches.

## 2.9 UNDERGROUND WARNING TAPE

A. General Requirements for Manufactured Warning Tape: Preprinted, color coded, with lettering indicating service

B. Polyethylene, 6” wide, 4 mills

C. Detectable, Polyester encased Aluminum foil, 6” wide, 5 mills

# 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 INSTALLATION, GENERAL 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.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

## 3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:
   1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

D. Nameplates shall be installed with corrosion-resistant mechanical fasteners. Do not use adhesives.

## 3.4 INSTALLATION OF PIPE LABELS

A. Label each mechanical and plumbing piping system.

B. Installed in accordance with the manufacturer's recommendations.

C. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

D. 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. Within 3 ft. of each valve and control device.
   2. At access doors, manholes, and similar access points that permit view of concealed piping.
   3. Within 3 ft. of equipment items and other points of origination and termination.
   4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

E. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation.

F. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

G. Pipe -Label Type Schedule:

| Location | Type |
|---|---|
| Interior, non-mechanical room | Self-Adhesive Pipe Labels |
| Interior Mechanical room | Pretensioned Pipe Labels |
| Exterior /Outdoors | Pretensioned Pipe Labels – non-vinyl chloride designed for outdoors |

H. Pipe-Label Color Schedule:
   Colors shall be as follows:

| Color Scheme ASME A13.1 | Fluid Service |
|---|---|
| White letters on Red Background | Fire quenching fluids |

| | |
|---|---|
| Black letters on Orange Background | Toxic and corrosive fluids |
| Black letters on Yellow Background | Flammable and oxidizing fluids |
| White letters on Green Background | Potable, cooling, roof drain , drain, waste, vent boiler feed, and other water |
| White letters on Brown Background | Combustible fluids |
| White letters on Blue Background | Compressed gases, non-flammable, non-toxic |

## 3.5 INSTALLATION OF DUCT LABELS

A. Label each duct system.

B. Installed in accordance with the manufacturer's recommendations.

C. Install duct labels showing service and flow direction with permanent adhesive on air ducts uninsulated or insulated, exposed or concealed, except for exposed ductwork in finished areas.

D. Labels shall be installed in clear view; installed on both sides of the duct; run parallel to the ductwork; located at not more than twenty-five foot (25') intervals on straight runs at all branch locations; and located on each side of penetrations of the building structure and non-accessible enclosures

E. Duct-Label Color Schedule:
1. For air supply ducts: White letters on blue background
2. For air return ducts: White letters on blue background
3. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.
    a. Outdoor air labels shall have an “air” legend.

## 3.6 INSTALLATION OF VALVE TAGS

A. Install tags on all valves exposed or concealed, unless indicated otherwise. shall be identified indicating the service of system the valve is in and the number of the valve. List tagged valves in a valve schedule in the operating and maintenance manual.

B. Valves that tags are not required:
1. Check valves
2. Balance valves that are not used as a combination balance/service valve
3. Valves within factory-fabricated equipment
4. Shut off valves for terminal equipment that are located with 6 feet of device with the pipe visible, and with no pipe branches located between the valve and the equipment.

C. Legends shall be HVAC, PLBG, SPR, and GAS.

D. Temperature control valves shall be identified with a ¼” “T.C.” legend and shall be numbered consecutively starting with major equipment and then terminal units (i.e., AHU-1 preheat, cooling, reheat control valves shall be numbered 1, 2, 3 respectively).

E. Chains shall be attached to the valve lever handle or around the valve stem.

F. An additional 10 consecutively numbered tags for each service shall be provided to the Owner for future use.

G. Service valves and isolation valves shall be labeled consecutively with supply being odd and return even (i.e., chilled water pump service valves shall be No. 1 on pump discharge and No. 2 on pump suction). Where a valve does not have a match skip the next number. All single valves for make-up water, expansion tanks, etc. can be numbered consecutively and shall be last in the sequence.

H. The existing systems in Craig Hall are identified and a list can be obtained from the Owner. Additions to the existing systems shall start numbering at a multiple of (10) plus (1) leaving a minimum of 10 valve numbers between the existing system and the new (i.e., if the existing numbering stops at 66, the new number shall be at 81). The existing numbering convention shall be followed as closely as possible.

## 3.7 INSTALLATION OF WARNING TAGS

A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

B. Attach warning tags, with proper message, to equipment and other items where indicated on Drawings, and herein.

C. Equipment that is controlled by the Building Automation Control System shall be labeled with a 2” x 5” label reading:
CAUTION – THIS EQUIPMENT IS UNDER COMPUTER CONTROL AND MAY CYCLE AT ANY TIME.

## 3.8 INSTALLATION OF WARNING TAPE

A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes

B. Install warning tape on pipes and ducts, at walkways or isles providing less than 6 ft. of clearance above finished floor including items located near the floor that are trip hazards.

C. Locate tape so as to be readily visible from the point of normal approach.

## 3.9 INSTALLATION OF UNDERGROUND WARNING TAPE

A. Install underground waring tape for each below grade pipe or conduit exterior to the building.

B. Warning tape shall be positioned approximately 6” below finished grade and directly above the piping / utility.
1. Metallic piping shall be identified with continuous polyethylene warning tape
2. Non-metallic piping shall be identified with continuous metallic detectable warning tape

C. The following legend, color, and lettering shall be used for below ground:

| Service | Color | Legend |
|---|---|---|
| Electric 4160 V | Red | Caution Buried High Voltage Electric |
| Electric | Red | Caution Buried Electric |
| Fiber Optic | Orange | Caution Buried Fiber Optic |
| Telephone | Orange | Caution Buried Communication |
| Sewer | Green | Caution Buried Sewer |
| Potable Water | Blue | Caution Buried Water |
| Non-potable Fire | Purple | Caution Buried Reclaimed Water |
| Steam | Yellow | Caution Buried Utility Line |
| Chilled Water | Purple | Caution Buried Reclaimed Water |
| Heating Water | Purple | Caution Buried Reclaimed Water |
| Condensate | Purple | Caution Buried Reclaimed Water |
| Irrigation Water | Purple | Caution Buried Reclaimed Water |

END OF SECTION 20 10 70

# SECTION 20 20 10 – ELECTRICAL REQUIREMENTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Motors
   2. Motor Controls
   3. Disconnect Switches
   4. Multi-speed Motors and Controls
   5. Variable Speed Drives
   6. Control Panel

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 GENERAL

A. This Subsection specifies the basic requirements for electrical components which are an integral part of "packaged" mechanical equipment. These components include, but are not limited to, factory installed motors, starters, disconnect switches, control panels and related prewiring of power and control wiring for a single external electrical service connection. All material and equipment shall be provided for the application and service intended.

B. Specific electrical requirements (e.g. horsepower, electric characteristics, etc.) for mechanical equipment shall be specified within the respective equipment specifications or shall be scheduled on the Plans.

C. The Contractor shall verify that electrical characteristics of material and equipment furnished for Divisions 20 - 25 equipment are in accordance with the electric service and comply with the specifications and requirements of Division 26 - 29.

D. Unless otherwise specified as an integral part of packaged mechanical equipment, motor control centers, motor starters and disconnect switches and the power wiring from power source to motor starting equipment (including variable frequency drive packages) and wiring from that equipment to the respective motors including final connections shall be performed as Electrical Work of Division 26 - 29.

E. The field installation of electrical components, not included in Division 26 - 29, that are specified to be provided with the mechanical equipment and are shipped separately shall be the responsibility of the Contractor furnishing the base equipment.

F. All electrical components and material shall be UL labeled.

G. Submittals for the applicable electrical equipment shall include the following: identification of the equipment which the electrical material is to serve, application, voltage, phases, full load amperage, wattage and NEMA enclosure. For motors: horsepower, RPM, full load power factor and efficiency, frame size and service factor.

H. Identification of electrical components of mechanical equipment shall be in accordance with "Basic Mechanical Methods - Identification".

1.3 REFERENCES

A. Electrical material and equipment provided for Divisions 20 - 29 shall meet the applicable requirements of the latest accepted edition of the following codes and standards:
1. ANSI American National Standards Institute
2. EEI Edison Electrical Institute
3. IEEE Institute of Electrical and Electronic Engineers
4. NEC National Electrical Code
5. NEMA National Electrical Manufacturers Association
6. UL Underwriter's Laboratories, Inc.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

2.2 MANUFACTURERS

A. Motors
1. Baldor
2. General Electric
3. Gould
4. Marathon

5. Magnetek
6. Reliance
7. Siemens
8. Toshiba
9. U.S. motors

B. Motor Controls
1. Allen-Bradley
2. Eaton
3. General Electric
4. Siemens
5. Square D

## 2.3 MOTORS

A. The following are basic minimum requirements for all motors. Additional motors, more detailed and specific requirements may be specified with the respective equipment.

B. Single-phase motors shall be provided for all motors 1/2 HP or less, except as specified or scheduled otherwise and shall be of the permanent split capacitor (PSC) type.

C. Polyphase motors shall be provided for all motors 3/4 HP or larger, except as specified or scheduled otherwise with a minimum power factor of .85 at 65% of full load or shall be power factor corrected.

D. Multi-speed motors shall have dual windings wound to the speeds scheduled or specified.

E. Torque characteristics shall be sufficient to satisfactorily accelerate the driven load(s) with low in rush current.

F. Motor horsepower sizes shall be large enough so that the driven load shall not require the motor to operate in the service factor range.

G. Temperature rating: Rated for 40 deg. C environment with maximum temperature rise for continuous duty at full load of 40°C for open dripproof motors, 50°C for splash proof motors, and 55°C for totally enclosed motors (Class B insulation). Motors used with variable frequency drives/inverters shall be NEMA MG1, Part 31 Compliant and have a Class B temperature rise with Class F insulation design to resist transient spikes, high frequencies, and short rise time pulses produced by inverters.

H. Starting capability: Frequency of starts as specified by the automatic control system. For manually controlled motors, not less than five (5) evenly time spaced starts per hour.

I. Service factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

J. Motor construction:
1. NEMA standard frame sizes, general-purpose open dripproof (unless otherwise specified), continuous duty, Design "B" (unless "C" is required for high starting torque). Motor frame, end bells and conduit box shall be cast iron; stator windings shall be copper. Aluminum is unacceptable for any parts. Provide grounding lug in motor terminal box.

2. Motors located outdoors or otherwise exposed to water, dust, etc where an open motor would not be suited, shall be totally enclosed fan-cooled (TEFC).
3. Bearings: Ball or roller bearings with inner and outer shaft seals. Externally accessible inlet/outlet grease fittings. Where motors are enclosed within equipment, extend grease tubing to exterior of the enclosure. Bearings designed to resist thrust loading for drives producing lateral or axial thrust. Fractional horsepower, light duty motors may have sleeve bearings.
4. Overload protection: Built-in thermal overload protection.
5. Noise rating: Motors shall meet IEEE, Standard 85.
6. Efficiency: Motors shall be NEMA Premium Efficiency per NEMA Standards Publication MG 1-2021.
7. Nameplate: Indicate full identification of manufacturer's name, model number, serial number, horsepower, speed, voltage, characteristics, construction, special features, etc. Nameplates in harsh environments such as for cooling towers, or in pool equipment rooms, etc. shall be suited to the specific application.
8. Comply with IEEE 841 for severe-duty motors

## 2.4 MOTOR CONTROLS

A. Motor Starters: NEMA 1, general-purpose enclosures with padlock ears, unless specified other wise. Type, size and duty shall be as specified or as recommended by the motor manufacturer and the requirements of the driven equipment for applicable protection and start-up conditions.

B. Manual Starters: Pilot light and extra positions for multi-speed motors. Melting alloy type thermal overload relay protection.

C. Magnetic Starters: Hand-off-Auto selector switches, pilot lights, interlock contacts, switches and other devices as required for control requirements. Trip-free thermal overload relays for each phase. Built-in 120 volt control circuit transformer, fused from line side, where power service exceeds 240 volts. Externally operated manual reset; under-voltage release of protection.

## 2.5 DISCONNECT SWITCHES

A. Fusible: For 3/4 horsepower and larger. Disconnect switch shall be horsepower-rated, heavy duty, spring reinforced fuse clips each phase, quick-make/quick-break mechanism with arc quenchers, dead front line side shield, solderless lugs, silver electroplated current carrying parts, lockable hinged door, capacity and electric characteristics as specified.

B. Non-fusible: For 1/2 horsepower motor and smaller. Disconnect switch shall be horsepower rated, toggle switch type, quantity of poles and voltage rating as specified.

## 2.6 MULTI-SPEED MOTORS AND CONTROLS

A. Multi-speed motors, when required, shall be specified under the heading of the respective equipment to be driven.

B. Motor controls for multi-speed applications shall be specified, also, under the heading of the respective equipment, if said equipment is a “packaged” type unit.

C. Otherwise, multi-speed motor controls shall be specified in Division 26.

## 2.7 VARIABLE SPEED DRIVES

A. Motor controls for variable speed drives shall be specified under the heading of the respective equipment, if said equipment is a “packaged” type unit.

B. Otherwise, variable speed drives shall be specified in Division 26.

## 2.8 CONTROL PANEL

A. NEMA 1 general-purpose enclosure for indoor application; NEMA 3R weather resistant enclosure for exterior location.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Provide motors, motor controls and accessories as specified and scheduled on the drawings.

B. Control Panel
1. Factory mount panel(s) and internal power and control devices. Pre-wire all devices for the operation of the related equipment so that only one main power connection shall be required in the field.
2. Provide internal protection for each circuit, maximum 120-volt secondary control transformer(s), terminal strips for wiring terminations, identification of components and wiring diagram inside the cover.

END OF SECTION 20 20 10

# SECTION 20 20 20 – DRIVES and GUARDS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: V-Belt Drives
   2. Direct-coupled Drives
   3. Guards

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. All drives shall be selected for 150% of specified motor nameplate horsepower.

### 2.2 MANUFACTURERS

A. V-Belt Drives
   1. Browning
   2. Eaton
   3. Gates

## 2.3 V-BELT DRIVES

A. All motors shall be provided with variable pitch pulleys with design RPM at mid-range of adjustment.

B. V-belts shall be premium quality, endless cord impregnated rubber with trapezoidal cross section, type A, B, C or D, matched set (if more than one), 95% minimum drive efficiency.

C. The driving motor shall be installed on an adjustable bolt device to provide for belt tension adjustment.

## 2.4 DIRECT DRIVES

A. Wherever available, motors and related direct driven equipment shall be mounted on a common base.

## 2.5 GUARDS

A. Guards shall be designed and arranged in accordance with OSHA requirements.

B. Guards shall completely enclose the drive, shall be secured to the respective equipment and shall be removable for servicing. Wherever available from the manufacturer, guards shall be provided with the equipment. If not, these shall be field fabricated.

C. Provide reinforced openings with removable cover plates for access to motor and driven shafts for speed measurement.

D. Extend tubing for grease fittings inside the guard to accessible locations outside the guard.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Provide drives of the type scheduled and specified with the associated equipment.

B. Provide OSHA guards on each rotating equipment with exposed rotating parts.

C. Install, balance and align all drives in accordance with the respective manufacturer's instructions and recommendations.

D. The balancing and alignment of drives including pinning, doweling and grouting shall be the responsibility of the Contractor furnishing the equipment. Any adversities arising from executing the Work shall be resolved/remedied by the Contractor.

E. Verify all electrical characteristics prior to running electric motor driven equipment. Check motor amperage draw and rotation for proper operation.

END OF SECTION 20 20 20

# SECTION 20 20 25 – INSULATION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Glass Fiber Insulation (aka Fiberglass)
   2. Elastomeric Foam Insulation
   3. Cellular Glass Insulation
   4. Metal jackets
   5. PVC covers
   6. Self-adhesive exterior duct jacket
   7. Mastics, Coatings, Sealants, & Adhesives
   8. Fasteners
   9. Fire Stop

B. Related Requirements:
   1. Section 20 00 00 BASIC MECHANICAL, PLUMBING, AND FIRE PROTECTION

C. Provide appropriate size calcium silicate/cellular glass/pipe shield manufactured inserts to the trade contractor for installation between the pipes and oversized hangers as specified in this section.

D. Fire wrap piping system located in occupied spaces or plenum spaces that do not meet flame spread 25 and smoke development 50.

### 1.2 DEFINITIONS

A. The term “fitting” where used in this Section of the Specifications shall be construed as an elbow, tee or reducer. Unions, flanges and valves shall not be considered as fittings.

B. The term “cold” shall be defined as the temperature of a surface that may result in the formation of condensation.

C. The term “accessory” shall include staples, bands, wire, mesh, clips, pins, studs, tape, anchors, corner angles, cements, adhesives, coatings, sealers, mastics, finishes, etc.

D. The term “ASJ” where used in this Section of the Specifications shall mean a reinforced vapor retarding All Service Jacket.

E. The term “SSL” where used in this Section of the Specifications shall mean Self-sealing Lap Joint closure system for longitudinal jacket joints.

F. The term “supply air” where used in this Section of the Specifications shall mean downstream of a coil.

G. The term “outdoor air” where used in this Section of the Specifications shall mean ambient air that has not been conditioned.

H. The term “return air” where used in this Section of the Specifications shall mean conditioned air that is returned from the space.

I. The term “mixed air” where used in this Section of the Specifications shall mean air streams that are a mixture of “outdoor air” and “return air”.

J. The term “relief air” where used in this Section of the Specifications shall mean excess return air that is relieved from the building.

K. The term “exhaust air” where used in this Section of the Specifications shall mean air that is removed due to contaminates, odors, or heat.

1.3 REFERENCES, REGULATORY REQUIREMENTS

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20 in addition to the following:
   1. State and local Air Pollution Codes and Regulations.
   2. NFPA 255/UL 723/ASTM E-84 Surface Burning Characteristics of Building Materials.
   3. UL 1479/ASTM E-814 Fire Test of Through-Penetration Firestops.
   4. ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation.
   5. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
   6. ASTM C1071 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
   7. ASTM C1290 Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
   8. ASTM C1136 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   9. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems.
   10. NFPA 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   11. North American Commercial and Industrial Insulation Standards. 9th Edition or Latest Edition. Published by Midwest Insulation Contractors Association (MICA).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Provide manufacturer's technical product data of each material and accessory item with engineering support information and recommended installation procedure. Indicate product number, “K” value, thickness and required accessories for each application.

B. Provide an insulation product schedule consisting of the following minimum information:
   1. Material - type of insulation material, jackets, or covers.
   2. Manufacturer - manufacturers name, product name, and K-value where applicable.
   3. Accessories - tapes, staples, coatings, adhesives including manufacturer's name and product name.
   4. Systems - indicate systems where product is used
   5. System - indicate which system insulation is installed.
   6. Location - inside, outside, concealed, exposed, etc.

7. Size - indicate size range of pipe, insulation type used.
8. Thickness - indicate insulation thickness in inches.

## 1.5 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

## 1.6 CLOSEOUT SUBMITTALS

A. Self-Adhesive Outdoor Jacket warranty information and copy of sales receipt and other information required for warranty claim.

## 1.7 QUALITY ASSURANCE

1. Contracting company shall be one specializing in insulation application and have a minimum of three (3) years experience in this work.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

C. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

D. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer for technical assistance and provide the Architect/Engineer with a copy of manufacturer's recommendation for approval.

## 1.9 WARRANTY

A. Self-Adhesive Outdoor Jacket shall have a 10 year manufacturer warranty.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Materials and accessories furnished for this Section of the Specifications shall be standard cataloged products, new, commercially available and suitable for the service specified.

B. Insulations materials shall not contain formaldehyde, asbestos, lead, mercury, mercury compounds, or polybrominated diphenyl ether fire retardants.

C. Fiberglass insulations shall be constructed of bio-soluble fiber, certified by EUCEB.

D. Fiberglass insulations shall have a minimum of 50 percent recycled glass content; certified and validated in accordance with UL 2809.

E. Fiberglass insulations shall have a bio-based, formaldehyde-free binder and be UL GREENGUARD Gold certified.

F. All insulation material shall have composite fire and smoke hazard ratings in accordance with NFPA 255 and UL 723 not exceeding the following values as tested by the latest procedures of ASTM E-84: flame spread of 25; smoke developed of 50.

G. Accessories such as adhesives, mastics, cements, tapes and cloths for seams, joints and fittings shall have the same ratings as hereinbefore listed. All products and their respective shipping cartons shall have indications that flame and smoke ratings meet the aforementioned requirements. Any treatment of jackets or facings to impart acceptable flame and smoke safety values shall be permanent; water-soluble applications are prohibited. The Insulation Contractor shall bear responsibility that all products to be used meet the foregoing criteria

### 2.2 MANUFACTURERS

A. Metal jackets
1. RPR Products, Inc.
2. Ideal Products
3. Johns Manville
4. Shur-Fit Products

B. PVC covers
1. Proto Corp. (Lo Smoke)
2. Speedline PVC Corp. (Smoke Safe)
3. Johns Manville (Zeston)
4. Shur-Fit Products
5. P.I.C. Plastics

C. Self-adhesive Exterior Duct Jacket
1. AlumaGuard All Weather by Polyguard Products
2. FlexClad by MTM Building Products
3. VentureClad by 3M

D. Mastics, Coatings, Sealants, & Adhesives
   1. Miracle Adhesives
   2. Vimasco Corporation
   3. Childers Products / H.B. Fuller Construction Products
   4. Foster Products / H.B. Fuller Construction Products
   5. Mon-Eco Industries

E. Fasteners
   1. ACS Industries
   2. GEMCO
   3. Midwest Fasteners

F. Fire Stop
   1. 3M
   2. Metacaulk
   3. Specified Technologies, Inc.
   4. USG Interior, Inc.
   5. Alkegen Unifrax
   6. Morgan Advanced Materials - Thermal Ceramics

G. Glass Fiber Insulation (aka Fiberglass):
   1. Knauf Insulation
   2. Manson Insulation
   3. Owens Corning
   4. Johns Manville
   5. CertainTeed

H. Elastomeric Foam Insulation:
   1. Armacell North America
   2. Aeroflex USA
   3. K-Flex USA

I. Cellular Glass Insulation:
   1. Owens Corning (Rigid Foamglas)

2.3 GLASS-FIBER PREFORMED FOR PIPE AND TUBE (Type GF1)

A. Glass fibers bonded with a bio-based thermosetting resin, non-combustible, complying with ASTM C547, Type I and IV, Grade A; ASTM C585, ASTM C411, ASTM C795. One piece, mandrel wound construction with factory pre-slit sidewall.
   1. Provide with factory-applied white ASJ+ SSL vapor retarder jacket with self-sealing lap closure and butt strips, complying with ASTM C1136.
   2. Maximum service temperature of 1,000 degrees F.
   3. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.23 Btu x in. /h x sq. ft. x degrees F, or less.
   4. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723.
   5. Must be NFPA 90A and 90B compliant, UL Environment GREENGUARD Gold certified, UL Validated Formaldehyde-free, UL Validated for Recycled Glass Content of 50% minimum.

B. Knauf Insulation Earthwool 1000 Pipe Insulation with ECOSE, Manson Insulation Alley-K Pipe Insulation with ECOSE, Owens Corning SS-II with ASJ or ASJ Max Fiberglas Pipe Insulation, or Johns Manville; Micro-Lok HP or HP Ultra Pipe Insulation

2.4 GLASS-FIBER PREFORMED FOR PIPE AND TANK (Type GF1A)

A. Glass fibers bonded with a bio-based thermosetting resin, non-combustible, complying with ASTM C547, Type I and IV, Grade A; ASTM C585, ASTM C411, ASTM C795. One piece, mandrel wound construction with factory pre-slit sidewall.
  1. Provide with factory-applied white ASJ+ SSL vapor retarder jacket with self-sealing lap closure and butt strips, complying with ASTM C1136.
  2. Maximum service temperature of 1,000 degrees F.
  3. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.23 Btu x in. /h x sq. ft. x degrees F, or less.
  4. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723.
  5. Must be NFPA 90A and 90B compliant, UL Environment GREENGUARD Gold certified, UL Validated Formaldehyde-free, UL Validated for Recycled Glass Content of 50% minimum.

B. Knauf Insulation Earthwool Pipe and Tank Insulation, Owens Corning Fiberglas Flexwrap with ASJ Max Fiberglas Pipe & Tank Insulation, or Johns Manville; Micro-Flex Pipe and Tank Insulation with AP facing.

2.5 GLASS-FIBER RIGID BOARD (Type GF2)

A. Glass fibers bonded with a bio-based thermosetting resin, non-combustible, complying with ASTM C612 (Type IA, IB).
  1. Provide insulation with factory-applied white ASJ+ facing complying with ASTM C1136.
  2. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.24 Btu x in. /h x sq. ft. x degrees F, or less.
  3. Maximum service temperature of 450 degrees F.
  4. Nominal density shall be 3.0 PCF.
  5. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723.
  6. Must be NFPA 90A and 90B compliant, UL Environment GREENGUARD Gold certified, UL Validated Formaldehyde-free, and UL Validated Recycled Glass Content of 50% minimum.

B. Knauf Insulation Earthwool Insulation Board with ECOSE, Manson Insulation; AK Board™ with ECOSE, Owens Corning Type 703 Insulation Board, Johns Manville; 800 Series Spin-Glas Insulation Board, or CertainTeed CertaPro Commercial Insulation Board.

2.6 GLASS-FIBER FLEXIBLE BLANKET (Type GF3)

A. Glass fibers bonded with a bio-based thermosetting resin, non-combustible, complying with ASTM C1290 and ASTM C553, Type I, II, and III.

1. Provide insulation with factory-applied white ASJ+ vapor retarding facing complying with ASTM C1136.
2. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.27 Btu x in. /h x sq. ft. x degrees F, or less.
3. Maximum service temperature of 250 degrees F with facing, 350 degrees F for unfaced material. Nominal density shall be 1.0 PCF and thickness to achieve required R-Value.
4. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723.
5. Must be NFPA 90A and 90B compliant, UL Environment GREENGUARD Gold certified, UL Validated Formaldehyde-free, and UL Validated for Recycled Glass Content of 50% minimum.

B. Knauf Insulation Atmosphere Duct Wrap with ECOSE, Manson Insulation; Alley Wrap™ B Duct Wrap with ECOSE, Owens Corning SoftR Duct Wrap, Johns Manville Microlite Duct Wrap, or CertainTeed; SoftTouch Duct Wrap.

2.7 FLEXIBLE ELASTOMERIC PREFOAMED FOR PIPE AND TUBE (Type F1)

A. Flexible elastomeric foamplastic with smooth exterior surface, preformed for pipe and tube application, ASTM C534, Type I, “k” value of 0.28 at 75 deg. F.

B. Armacell AP Armaflex pipe insulation, K-Flex LS tube, or AeroFlex EDPM tube.

2.8 FLEXIBLE ELASTOMERIC SHEET (Type F2)

A. Flexible elastomeric foamplastic with smooth exterior surface, sheet material, ASTM C534, type II, “k” value of 0.28 at 75 degrees F.

B. Armacell AP Armaflex sheet material, K-Flex LS sheet, or AeroFlex EDPM sheet.

2.9 RIGID FOAMGLASS PREFORMED FOR PIPE AND TUBE (Type FG)

A. Rigid foamglass preformed for pipe applications ASTM C552, K value of 0.33 at 75°F with all-purpose vapor retarder jacket.

B. Owens Corning Foamglas.

2.10 FACTORY-APPLIED JACKETS

A. Factory-applied Vapor Retarder Jacket - ASJ+-SSL is ASJ+ jacket equipped with Self-Sealing Lap Advanced Closure System; complying with ASTM C 1136 Type I, II, III, IV, and VII secured with self-sealing longitudinal laps and matching ASJ+ butt wraps.

B. Factory-applied Vapor Retarder Jacket - ASJ+ is All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a white kraft paper interleaving with an outer polymer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV, and VII.

## 2.11 FIELD-APPLIED JACKETS

A. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

C. Aluminum Jacket: Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Moister Barrier for interior and exterior applications: at least 3 mil polyfilm.
   2. Moister Barrier shall have ASTM E84 flame/smoke performance of ≤25/50.

D. Stainless steel Jacket: Stainless Steel Jacket: ASTM A240/A240M.
   1. Moister Barrier for interior and exterior applications: at least 3 mil polyfilm.
   2. Moister Barrier shall have ASTM E84 flame/smoke performance of ≤25/50.

# 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 INSTALLATION

A. Furnish and install insulation, jacketing, adhesives, sealants, and necessary accessories for the following systems where shown on the Plans and as hereinafter specified. Include all necessary considerations in the related sections of the Specifications (Subsection 20 25 03) to perform the Work completely.
   1. Chilled water piping (including chilled glycol and brine).
   2. Heating water piping.
   3. Combination chilled/hot (heating) water piping.
   4. Refrigerant piping suction, hot gas/discharge, heat recycling and reheat.
   5. Condensate drain piping.
   6. Waste piping and floor drains located above grade serving condensate drains.
   7. Make-up cold water piping.
   8. Low pressure (15# and less) steam supply piping.
   9. LP steam condensate return and condensate pump discharge.
   10. Medium pressure (16# to 50#) steam supply piping.
   11. High pressure (51# and over) steam supply piping.
   12. MP and HP steam condensate return and condensate pump discharge.
   13. Chilled water pumps, equipment and specialties.
   14. Reheat coils and return bends of uncased coils, including VAV boxes.

15. Heat exchangers and other heating equipment.
16. Ductwork/sheetmetal systems.
17. Domestic hot, hot recirculating and cold-water piping.
18. Domestic hot water storage tanks and other equipment.
19. Storm water drainage.
20. Heat traced piping (above grade).

B. Respective piping system, duct system and/or equipment shall be pressure tested, proved tight and accepted, as specified in section for installation of such, before insulation is applied. Sheet metal ductwork joints shall be sealed prior to insulating. Coordination among the respective contractors is essential.

C. Insulation materials and accessories shall be applied in accordance with respective manufacturer's recommendations and recognized industry practice for the insulation to serve its intended purpose. All surfaces to receive insulation shall be clean, dry, free of oxidation and prepared as required.

D. The insulation work shall be subject to inspection during the various applications and construction phases. Material, accessories, finishes, methods and workmanship that are not in compliance with these Specifications and/or approved submittals may lead to rejection of the Work and replacement at the Contractor's expense.

E. Tie-ins to existing systems and all new work shall be insulated to provide a complete and functional system. Finishes shall be compatible wherever possible.
   1. When existing insulation thickness is different than the specified thickness herein, the Contractor shall notify the Architect/Engineer. It is the intent that the existing piping would be restored to its original condition (thickness and finish) as if new work had not been performed.

F. Field-applied Insulation for Piping
   1. 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.
   2. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
   3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
   4. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
   5. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
   6. Painting of piping for corrosion protection, where specified, shall be performed before insulation is applied.
   7. Painting of piping for color coding, where specified, shall be performed after insulation is applied.
   8. Insulate each piping section with single thickness full-length units of insulation, with a single cut piece to complete the run where a fitting is encountered. Do not use cut pieces or scraps abutting each other.
   9. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
   10. Extend piping insulation without interruptions through walls, floors, and similar piping penetrations, except where otherwise specified.

11. Insulation on unions, flanges, valves, strainers, expansion joints, pump impeller housings and other equipment requiring accessible servicing shall be removable and reusable without damage. Items requiring periodic attention shall have covers and/or casings to contain the insulation.
12. All "cold" piping systems shall be insulated with type and thickness of material herein specified and shall have a continuous vapor retarder through all fittings, hangers, supports and sleeves.
13. In cold systems flanges, unions, valves, etc., shall be covered with an oversized pipe insulation section sized to provide the same thickness as on the main piping section. An oversized insulation section shall be used to form a collar between two insulation sections with low-density blanket insulation being used to fill gaps. Jacketing shall match that used on main piping system. Rough cut ends shall be coated with suitable weather and/or vapor resistant mastic as required by the system location and service. All valve stems must be sealed with caulking that allows free movement of the stem but provides a seal against moisture incursion.
14. In hot system flanges, unions, valves, etc., shall be left exposed; insulation ends shall be tapered and sealed to allow bolts to be removed or other required access.
15. The installation of cold piping systems shall use oversize (outside the thickness of the insulation) pipe hangers.
    a. Piping systems 3" and smaller, the Insulation Contractor shall replace temporary wood blocking with insulation of thickness as scheduled in this section of the specification. Metal pipe shields shall be placed between the pipe hanger and the insulation.
    b. Piping systems 4" and larger, the Insulation Contractor shall replace the temporary wood blocking with high density pre-formed insulation (i.e. calcium silicate, cellular glass) inserts with suitable characteristics for the weight, temperature and application and insulation protection shields at each hanger. The specified insulation should stop and start at the insert at the hanger locations. The insert shall be wrapped with vapor barrier jacketing. Circumferential joints shall be taped with vapor barrier tape and coated with vapor barrier sealant. B-Line, or equivalent, figure B-3380 through B-3384, 360 deg. calcium silicate insert/shields and figure B-3153 protection shields may be used or equivalent may be field fabricated per details submitted for approval.
    c. If in the event pipe hangers are not oversized, this Contractor shall notify the Engineer and the Contractor(s) who provided and/or installed hangers. Hangers shall be corrected before pipe is insulated.
    d. Where size on size hangers have been approved by the Engineer in writing for use in special situations, the insulator shall insulate the hanger and hanger rod with ½" Type F insulation. Pipe insulation shall terminate at each side of the hanger and have vapor barrier end joint butt strips. Hanger insulation shall overlap pipe insulation a minimum of 4" on each side of the hanger and secured to the pipe insulation with contact adhesive. Hanger rods shall be insulated for a minimum of 12" secured to the rod with contact adhesive and the end sealed with a bead of caulk.
    e. The Contractor shall adjust hangers after the insulation and pipe shields have been installed to provide an evenly supported piping system. No hanger shall bear the entire weight or not carry any weight of piping system.
16. Special requirements for fiberglass pipe insulation:
    a. Fiberglass pipe insulation, All Service Jacket/Self Sealing Lap (ASJ w/SSL) type, shall be installed with laps positioned to shed water, position at either 10 o'clock or 2 o'clock and shall not be visible to view. End joint butt strips shall be installed on all piping with ½" adhesive to adhesive overlap.

b. For piping systems using fiberglass insulation, the fittings shall be insulated with: double thickness molded fiberglass fittings, or preformed cellular glass fittings secured with twine or wire; or with flexible elastomeric foamplastic; at the Contractor's option. The pre-molded PVC fitting covers shall be installed over the fiberglass inserts and secured with SS tacks. Victaulic fittings or couplings shall be insulated with sheet elastomeric foam plastic insulation formed to the fitting and formed "collars" over all couplings encountered.

c. For piping systems using fiberglass insulation, butt joints in hot piping shall be made with 2" wide vapor barrier tape over butt joints. Butt joints in cold piping shall be made with a wet coat of vapor barrier lap cement on butt joints and seal joints with 2" vapor barrier tape. All pipe insulation ends shall be tapered and sealed.

d. On "cold" applications only, the following additional requirements shall apply: the premolded fittings shall be sealed with an approved vapor barrier retardant prior to installing the jacket materials. Premolded PVC fitting covers shall then be installed over the premolded inserts, all joints shall be sealed with vapor barrier cement and 2" vapor barrier tape on lap joints. Premolded stainless steel or aluminum fitting covers shall be installed per the manufacturer's instructions and a bead of clear silicon caulk applied to all joints. Straight lengths of insulation abutting all fittings shall have both ends sealed with vapor barrier cement to prevent "wicking" or moisture migration. At a maximum of twenty-one foot (21') intervals, joining ends of the butt joints shall be sealed with vapor barrier cement prior to butting together to prevent "wicking" or moisture migration.

17. For piping systems using elastomeric foamplastic insulation, joints and seams shall be sealed with manufacturer's recommended contact adhesive. Fittings shall be insulated from segments fabricated from pipe insulation or sheet material, secured and sealed with contact adhesive. Termination points and ends shall be sealed to the pipe to prevent backflow of condensation on the inside of the insulation. Any piping outdoors or otherwise exposed to UV or ozone provide two (2) coats of WB Armaflex or equivalent.

18. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

G. Field-applied Insulation for Equipment

1. Manufactured equipment (i.e. air handling equipment, terminal units, air device plenums, etc.) requiring insulation shall be specified in the respective equipment specifications to be factory insulated with internally applied liner or double wall casing.

H. Field-applied Insulation for Ductwork

1. Ductwork systems shall be insulated in accordance with the insulation schedules. Insulate each duct section with single thickness full length pieces. Do not use scraps abutting each other.

2. Extend insulation without interruptions through walls, floors, and similar penetration, except where otherwise specified.

3. "Cold" duct systems shall have insulation with a continuous vapor retarder through all fittings, hangers, supports, air devices, fire dampers, duct mounted coils, dampers, and other devices in the ductwork system, etc.

4. In "cold" duct systems, using rigid board or sheet elastomeric foam insulation, support angles, stiffener angles, ductmate flanges, etc. they shall be covered with an oversized insulation strip sized to provide the same insulation thickness as on the duct. Provide a minimum of 2" of overlap on each side of the obstruction.

5. Board insulation shall be properly cut and dry fitted to the surface to be insulated. Edges shall be neat and clean cut. No intermediate cut pieces shall be allowed on the bottom and sides of the ductwork. Insulation board shall be secured in place using mechanical fasteners such as welded pins or speed clips. Locate not less than 3” from each edge or corner and approximately 12” on centers on all sides. There shall be a minimum of two (2) rows of pins on the bottom of the duct and one (1) on the sides. Additional pins may be needed on the bottom to prevent sagging. All seams, joints, penetrations and breaks in the vapor retarder jacket shall be sealed with pressure sensitive tape matching insulation facing. Edges shall be provided with 28 ga. 1” x 1” aluminum corner beading properly secured and shall have the same facing material as the insulation board.
6. Flexible duct wrap insulation shall be cut properly and fitted to “stretchout” dimensions and a 2” piece of insulation removed from the facing at the end of the piece to form an overlapping staple and tape flap. Insulation shall be installed with facing outside so tape flap overlaps facing at the other end. Insulation shall be butted tightly. Seams shall be stapled on 6” centers with outward clinching staples. Adjacent sections of duct wrap insulation shall be butted tightly with the 2” tape flap overlapping and stapled. For horizontal oval ducts over 30” wide, duct wrap insulation shall be secured additionally to the bottom of the duct with mechanical fasteners such as pins and speed clip washers spaced on 18” centers to prevent sagging. All seams, joints, tears, punctures and other penetrations in the vapor retarder jacket shall be sealed with FRK backing pressure sensitive tape.
7. Stop and point insulation around access doors and damper operators to allow operation without disturbing insulation.
8. Where a duct run changes from interior lining to exterior application (or vice versa), there shall be a 6” overlap of insulation.
9. In "cold" duct system with internal duct insulation, with 1 1/2 " thickness flexible duct wrap, insulate air devices, fire dampers, duct mounted coils, dampers, and other devices in the ductwork system that are not internally insulated.

I. PVC Pipe Insulation Plenum Fire Wrap
1. Provide 1/2 inch minimum thickness fire resistant blanket wrap consisting of inorganic blanket encapsulated with a scrim-reinforced aluminum foil and overlap seam to provide a flexible, non-combustible enclosure for cables and PVC non-plenum rated pipe in return air plenums as tested to UL 910.
2. Plenum Wrap shall be tested in accordance with the following:
    a. ASTM C 411, ASTM C 518, ASTM E 84, ASTM E 136, and UL 910
        1) Maximum Flame Spread (Ft.) 0.01
        2) Maximum Smoke (Optical Density) 0.01
        3) Average Smoke (Optical Density) 0.00
    b. Surface Burning Characteristics (ASTM E 84)
3. Cut Fire Barrier Plenum Wrap to a length sufficient to wrap completely around the perimeter of the pipe, plus provide a longitudinal overlap of not less than 1 inch and an overlap of 1 inch, minimum, over the adjacent wrap section. Use aluminum foil tape to seal cut edges of the blanket. Temporarily secure Plenum Wrap in place using 3/4 inch wide filament tape. Install minimum 1/2 inch wide by 0.015 inch (28 gauge) thick stainless steel metal banding with stainless steel metal band clamp or 16 gauge galvanneal tie wire around the Plenum Wrap to hold it in place. Place the bands or tie wires 1/4 inch from each edge of the blanket and at the midpoint of the blanket, 11-3/4 in. on center. Tension the banding or tie wire to hold the Plenum Wrap snugly in place, compressing the foil but not cutting the foil.

4. PVC Piping Insulation Plenum Fire Wrap shall be 3M Fire Barrier Plenum Wrap 5A or approved equivalent.

J. Field-applied Protective Finish Jackets
1. Aluminum stainless steel jackets with moisture barrier shall be cut and fitted to size required.
2. Fold a ½” safety edge on exposed side, roll to diameter required and secure with ½” x 0.020” aluminum or ½” x 0.015” stainless steel bands respectively on 9” centers (4 bands per 3 foot section of jacketing).
3. Provide appropriate seals, and shed water toward low end of pitched piping.
4. Install lap on top quadrant (2 or 10 o'clock position) of outside diameter of insulation and line up bands and seals to present neat and workmanlike appearance.
5. Fitting covers shall be consistent with piping insulation jacketing.
6. Secure in place with SS screws or banding.
7. Seal with approved caulking.
8. Sharp edges shall be turned under or otherwise protected.

K. Field-applied Protective Finish Jackets
1. PVC jacketing for pipe shall be applied with the SSL lap positioned properly to facilitate solvent welding of the seam.
2. PVC fitting covers shall be installed with proper watershed and all joints sealed with solvent welding.
3. Penetrations in the jacketing for hangers, supports and other openings shall be sealed with silicone caulk to be weather, vapor and watertight.

L. Field-applied Self-Adhesive Jackets
1. Ensure that all surfaces are clean and dry; free from dust, oil and grease/silicone.
2. Install per manufacturer’s instructions.
3. When applying, partly peel back and crease the liner so enough adhesive is available to attach the jacketing in the correct position.
4. Apply with 3” overlap to provide weatherproof seal.
5. Position jacket so the edge of the sealing lap faces down.

## 3.3 INSULATION MATERIAL SCHEDULE I-1 (HOT AND COLD PIPING)

A. Chilled water supply and return piping
1. 2” and smaller
   a. Type F1
   b. Thickness – 3/4”
2. 2-1/2” through 5”
   a. Type F1
   b. Thickness - 1”
3. 6” and larger
   a. Type F1
   b. Thickness - 1-1/2”

B. Hot water (140°F and less) supply and return
1. 1-1/4” and smaller
   a. Type F1

b. Thickness - 1”
2. 1-1/2” and larger
a. Type F1
b. Thickness - 1-1/2”

C. Hot water (141°F – 200°F) supply and return
1. 1-1/4” and smaller
a. Type F1
b. Thickness - 1-1/2”
2. 1-1/2” and larger
a. Type F1
b. Thickness - 2”

D. Combination chilled/hot (heating) water supply and return piping
1. All sizes
a. Type F1
b. Thickness - 1-1/2”

E. Low pressure steam condensate return piping including condensate pump discharge
1. 1-1/4" and smaller
a. Type GF1
b. Thickness - 1-1/2”
2. 1-1/2” and larger
a. Type GF1
b. Thickness - 2”

F. Low pressure (15# and less) steam supply
1. 3” and smaller
a. Type GF1
b. Thickness - 2-1/2”
2. 4” and larger
a. Type GF1
b. Thickness - 3”

G. Steam supply (16# to 120#)
1. 3/4” and smaller
a. Type GF1
b. Thickness - 3”
2. 1" and 1-1/4"
a. Type GF1
b. Thickness - 4”
3. 1-1/2” and larger
a. Type GF1
b. Thickness - 4-1/2”

H. Electrically heat traced piping
1. All sizes
a. Type as specified for the system.
b. Thickness - 1-1/2”

I. Domestic water- hot, hot recirc.

1. 2” and smaller
   a. Type F1
   b. Thickness - 1”
2. 2-1/2” and larger
   a. Type F1
   b. Thickness - 1-1/2”

J. Domestic water-cold
1. All sizes
   a. Type F1
   b. Thickness - 1/2”

K. Storm water from the roof drain to the first floor level below the roof. Thereafter, all horizontal piping only and related elbows to vertical.
1. All sizes
   a. F1
   b. Thickness - 1”

L. Storm water roof drain body
1. All sizes
   a. F2
   b. Thickness - 1/2”

M. Condensate Drain Lines:
1. All sizes except air handling units in Mechanical Rooms where drain line is 2'-0” or less in total length and located at the Mechanical Room floor.
   a. Type F1
   b. Thickness – 1/2”

N. Waste Piping and Floor Drains:
1. All sizes, piping above grade serving floor drains, hub drains, indirect cabinets, etc., that receive condensate from cooling coils. Insulate piping to where it connects to main waste pipe.
   a. Type F1
   b. Thickness – 1/2”

O. Sump Pump Discharge Lines:
1. All sizes
   a. Type F1
   b. Thickness – 1/2”

P. Fittings (hot and cold):
1. All sizes
   a. Molded/preformed fittings, matching insulation type, secured in place with twine or tape, seal all “cold” applications prior to installing jacket material.
   b. Thickness – matching adjacent piping

Q. Unions, flanges, valves: (cold piping):
1. All sizes
   a. Type F1
   b. Thickness – matching adjacent piping

c. Form external collar, minimum 1" overlap on adjacent insulation. Use adhesive to secure in place and maintain vapor barrier.

R. Unions, flanges (hot piping):
1. All sizes
a. No insulation.

S. Valves (hot piping):
1. All sizes, insulate valve body only
a. Type: match adjacent piping
b. Thickness – matching adjacent piping

T. Joints, lines subject to condensation:
1. All sizes
2. Seal longitudinal laps of jacket with adhesive and wrap butt joints between sections with 2" wide tape.

3.4 INSULATION MATERIAL SCHEDULE I-2 (COLD EQUIPMENT)

A. Chilled (cold) surfaces, not factory insulated, interior application
a. Type F2
b. Thickness – 3/4"

B. Air separator (Rolairtrol unit)
a. Type F2
b. Thickness - 1"

C. Pump impeller housing
a. Type F2
b. Thickness - 1"

D. Water boxes of chilled water heat exchangers
a. Type F2
b. Thickness - 1"

E. Fittings:
1. All sizes
a. Type F1
b. Thickness - 1"

F. Unions, flanges, valves:
1. All sizes
a. Type F1 or F2
b. Thickness - 1"

G. Joints and seams: Seal with Armstrong 520 adhesive.

H. Finish, interior: No additional finish required.

I. Finish, exterior: Seal with (2) coats of WB Armaflex

J. Hangers, supports: Outside insulation with continuous vapor barrier. (This may be difficult to accomplish, particularly if equipment is heavy. If hanger or support is in direct contact with equipment, insulate immediate support and connecting member(s) for length of 12” away.)

## 3.5 INSULATION MATERIAL SCHEDULE I-3 (HOT EQUIPMENT)

A. Heat exchangers
1. Type: GF2, or GF1 or GF1A for round surfaces
2. Thickness - 2”

B. Steam condensate receivers
1. Type: GF2, or GF1 or GF1A for round surfaces
2. Thickness - 2”

C. Condensate and flash tanks
1. Type: GF2, or GF1 or GF1A for round surfaces
2. Thickness - 2”

D. Hot water pump impeller housings
1. Type: F2
2. Thickness - 2”

E. Air separator (Rolairtrol unit)
1. Type: F2
2. Thickness - 2”

F. Flanges: No insulation.

G. Attachment:
1. Secure rigid board with welded pins on 12” centers.
2. Secure with ¾” x 0.020” SS bands on 12” centers. Fit ends of tanks and irregular surfaces by segmenting or scoring board and wiring into place.

H. Joints:
1. Point and fill-in all joints and voids with insulating cement or fill-in all joints and voids by stuffing with mineral wool.

I. Jacket:
1. 0.016” smooth aluminum jacket with moisture barrier, secured with ½” x 0.015” SS bands on 9” centers and SS sheet metal screws.

## 3.6 INSULATION MATERIAL SCHEDULE I-4 (DUCTWORK 0 to 250 degrees F)

A.

A. Outdoor Air, Return Air and Mixed Air Plenums, and Filter sections
 a. Type: GF2
 b. Thickness - 1”

B. Round and oval Supply Air
 a. Type: GF3
 b. Thickness – 1-1/2”
 c. (Refer to Division 24 and drawings for location of K-27 double wall ducts)

C. VAV box coil return bends
 a. Type: GF3
 b. Thickness – 1-1/2”

D. Outside Air and Mixed Air ducts
 a. Type: GF3
 b. Thickness – 1”

E. Outside of the Building Insulation Envelope
 1. Rectangular Supply Air, Heated or Cooled Make-up/Ventilation Air
  a. Type: PI2
  b. Thickness - 2”
  c. Provide tapered insulation on top surface to prevent ponding on ductwork.
  d. Jacket: Self-adhesive, field-applied outdoor jacket
 2. Round or Oval Supply Air, Heated or Cooled Make-up/Ventilation Air
  a. Type: GF1A
  b. Thickness - 3”
  c. Jacket: Self-adhesive, field-applied outdoor jacket
  d. (Refer to Division 24 and drawings for location of K-27 double wall ducts)
 3. Duct mounted coils
  a. Type: PI2
  b. Thickness - 2”
  c. Provide tapered insulation on top surface to prevent ponding on ductwork.
  d. Jacket: Self-adhesive, field-applied outdoor jacket
 4. Rectangular Return Air
  a. Type: PI2
  b. Thickness – 1-1/2”
  c. Provide tapered insulation on top surface to prevent ponding on ductwork.
  d. Jacket: Self-adhesive, field-applied outdoor jacket
 5. Round or Oval Return Air
  a. Type: GF1A
  b. Thickness - 2”
  c. Jacket: Self-adhesive, field-applied outdoor jacket
  d. (Refer to Division 24 and drawings for location of K-27 double wall ducts)
 6. Outdoor Air and Mixed Air N/A
 7. Outdoor Air and Mixed Air Plenums, and Filter sections N/A
 8. Relief Air N/A
 9. Exhaust Air N/A

F. Fire Rated Insulation Applications
   1. Rectangular Ductwork
      a. Type: FR1
   2. Round Ductwork
      a. Type FR2

## 3.7 JACKET MATERIAL SCHEDULE I-5

A. Finish insulation with factory or field application for respective locations as follows:

B. Dry, low abuse (indoor): Concealed, not exposed to view; mechanical equipment rooms; exposed, finished spaces.
   1. Pipe: ASJ jacket.
   2. Pipe Fittings: Pre-molded PVC covers.

C. High abuse area: Exposed vertical risers in all Storage Rooms, Janitor Closets; Exposed, unfinished spaces.
   1. Pipe: 304 Stainless steel jacket, smooth, 0.010 inch thick, with seam away from abusive force. Apply to height of 8 feet.
   2. Pipe Fittings: Formed stainless steel covers.

D. Outdoors: All
   1. Pipe: Aluminum jacket, smooth
   2. Pipe Fittings: Formed aluminum covers.
   3. Thickness:

| Outer Insulation Diameter (in) | Min. Aluminum Jacketing Thickness (in) | |
|---|---|---|
| | Rigid Insulation | Non-Rigid Insulation |
| ≤8 | 0.016 | 0.016 |
| Over 8 thru 11 | 0.016 | 0.020 |
| Over 11 thru 24 | 0.016 | 0.024 |
| Over 24 thru 36 | 0.020 | 0.032 |
| >36 | 0.024 | 0.040 |

END OF SECTION 20 20 25

# SECTION 21 00 00 – FIRE PROTECTION SYSTEM

## 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. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 21 of these Specifications.
   1. Section 21 00 10 – Fire Protection Design
   2. Section 21 00 20 – Piping and Accessories
   3. Section 21 00 30 – Wet Pipe Sprinkler System
   4. Section 21 00 40 – Dry Pipe Sprinkler System

C. The following section of the Specifications apply to Work under this Section
   1. Division 20 - Basic Mechanical, Plumbing, and Fire Protection
   2. Division 26 - Electrical
   3. Division 28 – Electronic Safety and Security

### 1.2 SUMMARY

A. Section Includes:
   1. Wet pipe systems for areas not subject to freezing.
   2. A dry pipe system, including an air compressor, for areas subject to freezing, and where indicted on the drawings.
   3. A dry standpipe system including [hose, valve] cabinets and fire department valves.
   4. All required fire department connections,.
   5. Water supply including backflow prevention devices, vaults, meter, detector check, post indicating valves, etc.

### 1.3 QUALITY ASSURANCE

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20.

B. All operable devices and features of sprinkler system, accessories, equipment and specialties provided for in the Scope of Work of this Section shall be operated and proved to function satisfactorily for a period of forty-eight (48) hours. Adjust, balance, lubricate as required, and instruct the Owner in the proper operation and maintenance of each device.

C. Sprinkler system, equipment and specialties shall be protected against damage in the period between installation and acceptance. Any item damaged shall be removed, repaired and/or replaced at no additional compensation.

D. Place plugs in the ends of uncompleted piping at the end of each day or when work stops.

E. Where pipe and accessories installed under this section of the specification tie-in to existing systems, Contractor shall verify existing for: sizes, materials, and elevations before installing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

## 1.4 ACTION SUBMITTALS

A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Refer to Division 1, Division 20, and each section of Division 21.

## 1.5 INFORMATIONAL SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 21.

## 1.6 CLOSEOUT SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 21.

B. At the completion of the project, submit a letter stating all materials are asbestos free, and meet the specified ASTM E-84 flame/smoke rating of 25/50, and that all piping and duct penetrations are smoke or fire stopped as required by the Code.

# PART 2 - PRODUCTS (Not Applicable)

# PART 3 - EXECUTION (Not Applicable)

END OF SECTION 21 00 00

# SECTION 21 00 10 – FIRE PROTECTION DESIGN

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Performance Requirements
   2. Water Supply
   3. Delegated Design.

B. Related Requirements:
   1. Section 21 00 00 FIRE PROTECTION SYSTEMS

### 1.2 REFERENCES

A. Applicable requirements of the current and accepted edition of the following industry standards, codes and specifications shall apply to the Work for Division 21
   1. ANSI American National Standards Institute
   2. National Fire Protection Association (NFPA) 13, 2010.
   3. National Fire Protection Association (NFPA) 14, 2010.
   4. UL Underwriters Laboratory, Inc.
   5. Owner’s Insurance carrier: FM Global.

### 1.3 ACTION SUBMITTALS

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

B. Submittal drawings shall show lights, ducts, and pipes indicating all necessary rises and drops in sprinkler piping required for routing. Drawings shall be of a minimum of the same scale as the contract documents (1/8” = 1'-0” scale.) A ¼” scale drawing of the service entrance and an elevation of the service entrance shall be required. A sprinkler riser diagram showing all control valves, test connections, supervisory switches, and drains shall be required.

C. The “layout” submittals shall be provided as PDF drawings of the piping layout.

D. Any pipe sizing or hydraulic calculations performed prior to the Contractor receiving the “layout” submittal with the 'approved stamp' of the Engineer shall be at the Contractor's own risk. Any design changes resulting in resizing pipe and/or revising hydraulic calculations will be done at no cost to the Owner.

E. The “working drawing” submittals shall be provided as PDF drawings of the piping layout and include hydraulic calculations. Calculations shall include peaking information for each area calculated. The hydraulic calculation used for the system design shall be clearly identified from all other hydraulic calculations and should show the safety factor the designed system has relevant to the available water test pressure.

F. Hydraulic calculations shall include: actual pipe internal diameters and coefficients of materials approved in the “layout” submittal; design density; remote area size; and area per sprinkler.

G. The Contractor shall not pursue any approvals or interpretations of the design documents except through the office of the Architect/Engineer.

H. All work shall meet the requirements of the Owner, authority having jurisdiction, FM Global, Architect and Engineer. These requirements may be greater than required by NFPA. Work shall not start prior to the Contractor receiving the “working drawing” shop drawings with the 'stamp' of the Engineer and approval from the authority having jurisdiction.

I. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

1.4 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:
   1. Notify Owner no fewer than 14 days in advance of proposed interruption of sprinkler service.
   2. Do not proceed with interruption of sprinkler service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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. Sprinkler system equipment, specialties, accessories, installation, and testing to comply with NFPA 13 and FM Global.

C. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

D. Pipe velocities shall not exceed 14 feet per second in any section of the piping system.

## 2.2 WATER SUPPLY

A. A. The water supply shall be a connection to the campus fire water supply.

B. A new flow test witnessed by the Fire Marshal shall be conducted.

C. Design water pressure requirements shall include a minimum of 10-psi safety factor. Where Authority having jurisdiction requires a higher safety factory it shall be used.

## 2.3 DELEGATED DESIGN

A. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 20 percent, the 20% <u>includes</u> all losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Light Hazard Areas:
   a. Office and Public Areas
   b. Corridors
   c. Meeting Rooms
   d. Locker Rooms
   e. Multi-Purpose Rooms
   f. Vestibules
   g. Stairs
3. Sprinkler Occupancy Ordinary Hazard, Group 1 Areas:
   a. Electrical Rooms
   b. Mechanical Rooms
   c. Elevator Equipment Room
   d. Janitor’s Closets
   e. Storage Rooms – Stacks up to 8’ in height
4. Sprinkler Occupancy Ordinary Hazard, Group 2 Areas:
   a. Storage Rooms – Stacks up to 12’ in height
   b. Shops – Wood Working or Metal Working
   c. Stages
5. The hazard protection level shall be increased as required for areas with hazardous materials, flammable and combustible liquids, or storage that requires additional protection per NFPA 13. The sprinkler design criteria for spaces with hazardous materials and/or flammable and combustible liquids shall be in accordance with NFPA 30 and the requirements for Extra Hazard occupancies of NFPA 13.
6. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard: 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.

7. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

   a. Light-Hazard Occupancies: 100 gpm for 30 minutes.

   b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.

8. Reduction in design area shall be permitted for quick response sprinklers in accordance with NFPA 13.

B. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and Division 21 “Seismic Protection”.

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.

C. Contractor shall use manufacturer’s pressure drop data in hydraulic calculations for flexible hoses piping connections where applicable and installed per the specifications.

3.2 INSTALLATION

A. Provide a complete code compliant [and Factory Mutual (FM) approved] fire protection system as indicated by drawings and specifications related to this section.

B. The “layout” shall be submitted to the Architect prior to performing hydraulic calculation, sizing pipes or seeking approvals from the authority having jurisdiction.

C. The Architect/Engineer will review “layout” for aesthetics, and pipe routings for consistency with the construction documents.

D. Minimum head spacing shall be as per NFPA-13 and FM Global (most strict of the two). Additional heads may be required by the Architect/Engineer to create spacing that works with the reflected ceiling plans. Contractor shall layout any areas not shown on the plans with symmetry and “rhythm” in mind.

E. Heads shall be on return bends and centered ± 1” for 2' x 2' ceiling tiles, or on quarter points ± 1” for 4' x 2' ceiling tiles.

F. Contractor shall not scale the drawing, refer to architectural drawings for dimensions. Where the room dimension is at the maximum size listed for the sprinkler heads, install an additional row of sprinklers.

G. Contractor shall locate heads in the field from the final wall locations. It shall be brought to the Architect’s/Engineer’s attention where the center of tile location exceeds the maximum distance of the sprinkler. Additional heads shall be added and the layout modified as directed by the Architect/Engineer at no additional cost to the Owner.

H. All sets and rises shall be located above ceilings of adjacent spaces of rooms without ceilings as opposed to making the sets and risers in the exposed spaces.

I. Inspector test connections and auxiliary drains shall be piped to spaces not occupied by building occupants, i.e., Mechanical Rooms, Storage Rooms, Janitor's Closets, etc.

END OF SECTION 21 00 10

# SECTION 21 00 20 – PIPING AND ACCESSORIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
  1. Backflow prevention device
  2. Fire department hose connections
  3. Flexible hoses
  4. Piping and Fitting Material
  5. Pressure gauges
  6. Supervisory switch
  7. Valves
  8. Water flow switch

B. Related Requirements:
  1. Section 21 00 00 FIRE PROTECTION SYSTEMS

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

### 1.5 EXTRA MATERIALS

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 two (2) heads of each sprinkler head plus sprinkler wrench(es). Where this quantity is less than what is required by NFPA 13, provide additional heads in proportion to the types and temperatures utilized throughout the building.

PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 BACKFLOW PREVENTION DEVICE

A. Double Check Valve Assembly with OS&Y gate shutoff valves.
   1. Assembly shall consist of two independently operated spring loaded cam-check valves, OS&Y resilient seated gate shut-off valves, and required test cocks.
   2. Basis of Design:
      a. Watts Series 757/774
      b. Ames Series 200/2000
      c. Zurn Series 350
      d. Apollo Series DC4A
   3. Pressure Loss: 5 psig maximum, through middle one-third of flow range.

## 2.3 FIRE DEPARTMENT HOSE CONNECTIONS

A. General Requirements:
   1. Furnish and install fire department connections (FDC) as indicated on the plans.
   2. Standard: UL 405.
   3. Pressure Rating: 175 psig minimum.
   4. Body Material: Cast Brass
   5. Body Type: Clapper
   6. Includes: Identification plate, caps, and chains
   7. Finish: See below.
   8. Hose Threads shall be according to NFPA 1963 and shall conform to the local fire department standards. Include extension pipe nipples, brass lugged swivel connections.
   9. Labeling shall be **"AUTO SPRINKLER".**

B. Flush Inlets (Craig Hall):
   1. Basis of Design:
      a. Potter Roemer Series 5000
      b. Guardian Series 6000
      c. Elkhart Brass
      d. American Fire Supply
   2. Finish: Polished brass

C. Free Standing (Annex Building):
   1. Basis of Design:
      a. Potter Roemer Series 5000
      b. Guardian Series 6200
      c. Elkhart Brass model 15

d. American Fire Supply
2. Finish: polished chrome

## 2.4 FLEXIBLE HOSES

A. General Requirements:
1. Standard: UL 1474
2. Factory leak tested, fully welded, stainless steel (1" minimum internal diameter) corrugated pressure hose and braided stainless steel outer jacket.
3. Mechanical fittings or O-rings shall not be installed/accepted.
4. Length: Maximum 48"
5. System shall be manufactured by Flexhead, a Division of Anvil International, no substitutions allowed.

## 2.5 STEEL PIPE AND FITTINGS

A. General Requirements:
1. Comply with requirements of this section for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
2. Manufacturers:
a. Anvil International, Inc.
b. Tyco Fire & Building Products
c. Victaulic Company

B. Standard-Weight Schedule 40 Steel Pipe: black steel pipe, ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

C. Steel Pipe Nipples: black steel, ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

D. Steel Couplings: Galvanized and uncoated steel, ASTM A865/A865M, threaded.

E. Gray-Iron Threaded Fittings: Galvanized and 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 thick
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. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

J. Grooved-Joint, Steel-Pipe Appurtenances:
1. Pressure Rating: 175-psig minimum.
2. Grooved-End Fittings for Steel Piping: Painted grooved-end fittings, ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
3. 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.

K. <u>The following types of fittings are prohibited</u>: plain end couplings and fittings, saddle/mechanical/clamp branch tee, grooved flange rings, and grooved reducing couplings.

## 2.6 PRESSURE GAUGES

A. General Requirements:
1. Standard: UL 393
2. Size: ¼ NPT or larger
3. Dial Size: 3-1/2 inch
4. Pressure Gauge Range: upper limit at least twice the normal working pressure

## 2.7 SUPERVISORY SWITCH

A. General Requirements:
1. Standard: UL 753
2. Housing: Rust Resistant
3. Switch mechanism: Form C contacts at 10A/120VAC or 2A/24VDC suitable for operation at 120-volt A.C. or 24-vold D.C.
4. Tamper-proof.
5. Manufacturer: Potter-Roemer model OSYSU-2 or equivalent

## 2.8 VALVES

A. General Requirements:
1. Valves shall be UL listed and FM approved.
2. Minimum pressure rating: 175 psi.
3. Listed for use in fire protection systems.

B. OS&Y Gate Valves:
1. Standard: UL 262
2. Body and Bonnet Material: Cast or ductile iron
3. Wedge: Cast or ductile iron
4. Wedge Seat: Cast or ductile iron
5. Stem: Brass or bronze
6. Packing: Non-asbestos PTFE
7. Supervisory Switch: External
8. Gear Operator: Manual
9. Position indicator

C. Butterfly Valves:
1. Standard: UL 1091
2. Body Material: Cast or ductile iron with nylon, EPDM, epoxy or polyamide coating.
3. Seat Material: EPDM
4. Stem: Stainless Steel
5. Disc: Ductile iron
6. Actuator: Manual gear
7. Supervisory Switch: Internal.
8. Body Design: Groove-end connections.

D. Drain Valves:
1. Standard: UL listed
2. Type: MSS SP-80, Type 2
3. Body Material: Forged brass or bronze
4. Class: minimum 125
5. End Connections: threaded or grooved-end

E. Check Valves:
1. Standard: UL 312
2. Type: Swing check.
3. Body Material: Cast iron, ductile iron, or bronze.
4. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
5. Clapper Seat: Brass, bronze, or stanless steel
6. Hinge Shaft: Bronze or stainless steel
7. Hinge Spring: Stainless steel
8. End Connections: flanged or grooved-end
9. Where used on fire department connections, valve shall have integral ball drip

F. Flow Test and Drain Valves:
1. Standard: UL listed
2. Type: Ball valve with sight glass
3. Manufacturers: Guardian model # 9215 or equivalent

G. Post Indicator Valve:
1. Standard: UL 789.
2. Type: Adjustable Height
3. Body Material: Ductile iron
4. Bonnet: Ductile iron.
5. Bonnet/Body Coating: Fusion bonded epoxy coating.
6. Operation: Handwheel
7. Gate Material: Cast iron, EPDM coated.
8. Manufacturers:
   a. Kennedy Valve model 2945A
   b. Mueller model A-20806
   c. Victaulic series 774
   d. Or approved equal.

## 2.9 WATER FLOW SWITCH

A. General Requirements:

1. Standard: UL 346
2. Water Flow Detector: Electrically supervised
3. Type: Paddle-operated
4. Pressure: 250 psig
5. Installation: Horizontal or vertical
6. Switch Mechanisms: Form C contacts at 10A/120VAC or 2A/24VDC suitable for operation at 120-volt A.C. or 24-vold D.C.
7. Dust tight construction and tamper-proof
8. Manufacturers: Potter-Roemer model VSR-F or equivalent.

## 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.

F. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

G. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION, PIPING

A. Hydrostatically test at not less than 200 psi for two (2) hours per NFPA 13.

B. Provide retainer glands where flanged ductile iron pipe is installed at point of building entry.

### 3.3 INSTALLATION, BACKFLOW PREVENTION DEVICE

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install in accordance with requirements of plumbing and health department and authorities having jurisdiction.

## 3.4 INSTALLATION, FIRE DEPARTMENT HOSE CONNECTIONS

A. Provide with a UL 1726 ball drip installed at the low point of the piping at each check valve for fire-department connection. For free-standing fire-department connections with an underground ball drip, provide drainable fill at ball drip as required to allow for proper drainage.

## 3.5 INSTALLATION, WATER FLOW SWITCH

A. Install on the sprinkler system as indicated and where required by NFPA.

B. Detectors shall be mounted in accordance with the manufacturer's instructions.

C. Detectors shall be designed to signal any flow of water that equals or exceeds 10 gpm.

D. Detector switch mechanisms shall incorporate and instantly recycling pneumatic retard element with an adjustable range of 0 to 60 seconds.

E. Detector shall be furnished and installed under this Section and wired complete under Division 26.

## 3.6 INSTALLATION, SUPERVISORY SWITCH

A. Switch shall be installed on all indicating and zone shut-off valves.

B. Switch shall be mounted so as not to interfere with the normal operation of the valve.

C. Switch shall be adjusted to operate within two revolutions of the valve control or when the stem has moved no more than one-fifth of the distance from its normal position.

D. Switch shall be arranged to cause a switch operation if the housing cover is removed or if the unit is removed from its mounting.

E. Switch shall be furnished and installed under this Section and wired complete under Division 26.

## 3.7 INSTALLATION, VALVES

A. Provide all necessary components including non-rising stem gate valve at post indicator valve location.

B. Coordinate installation of post indicator valve with fire alarm monitoring circuit.

C. 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.

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. Install permanent identification signs indicating the portion of system controlled by each valve. Each valve shall have a unique identifier that shall be in alignment with the current campus identification standards.

## 3.8 INSTALLATION, PRESSURE GAUGES

A. Furnish and install pressure gauges at locations shown on plans and where required for flow testing.

B. Each gauge shall have a shutoff valve and be arranged for draining without disturbing the gauge.

## 3.9 INSTALLATION, SPARE HEAD CABINET

A. Furnish and install at the fire protection service entrance.

## 3.10 INSTALLATION, FLEXIBLE HOSES

A. Provide flexible piping connections to sprinkler heads installed in ceilings, walls, or ducts.

B. Straight hoses may be used where space allows.

C. Ninety-degree elbow type hoses shall be used where space does not allow straight type.

D. Provide brackets and mounting hardware required for installation.

## 3.11 INSTALLATION, UNDERGROUND PIPING

A. Provide retainer glands where flanged ductile iron pipe is installed at point of building entry.

B. Hydrostatically test underground piping at not less than 200 psi for two (2) hours per NFPA 13, Section 8-2.2.

## 3.12 PIPING SCHEDULE, UNDERGROUND

A. General Requirements:

1. Comply with requirements of this section for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
2. Manufacturers:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products
   c. Victaulic Company

B. <u>The following types of fittings are prohibited</u>: plain end couplings and fittings, saddle/mechanical/clamp branch tee, grooved flange rings, and grooved reducing couplings.

C. Size: All below grade.
   1. Pipe: Ductile iron.
   2. Fitting: Ductile iron.
   3. Joints: Mechanical with restrained joints.

END OF SECTION 21 00 20

# SECTION 21 00 30 – WET PIPE SPRINKLER SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Wet pipe sprinkler system
   2. Sprinkler heads

B. Related Requirements:
   1. Section 21 00 00 FIRE PROTECTION SYSTEMS

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 SPRINKLER HEADS

A. General Requirements:
   1. Sprinkler heads shall be UL listed and FM approved.
   2. Type: Quick response, liquid in glass bulb.
   3. Minimum Pressure: 175 psi
   4. Minimum orifice: ½ inch, ½" inch NPT
   5. Minimum K-factor: 5.65
   6. Sprinklers with orifice larger than ½ inch shall be ¾ inch NPT.

7. Default sprinkler head type areas with ceilings to be concealed type.

B. Concealed Sprinklers:
1. Cover plate: “White Uno” factory finish. Different colors or custom color matches called out as required on the drawings.
2. Manufacturer:
a. Viking model Mirage VK462
b. Tyco model RFII
c. Reliable model G4QR.

C. Upright and Pendent Sprinklers:
1. Finish: Natural bronze, black factory finish, or white factory finish as called out on drawings.
2. Manufacturer:
a. Viking model Microfast VK300/310
b. Tyco model TY-FRB
c. Reliable model F1FR

D. Sidewall Sprinklers:
1. Type: Horizontal concealed
2. Cover plate: “White Uno” factory finish. Different colors or custom color matches called out as required on the drawings.
3. Manufacturer:
a. Viking model Microfast VK481
b. Tyco model RFII HSW
c. Reliable model G6-56

## PART 3 - EXECUTION

### 3.1 INSTALLATION, PIPING

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

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.
2. 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 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 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 "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

F. Install sprinkler piping with drains for complete system drainage.

G. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

H. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

I. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than 1/4 inch and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

J. Hydrostatically test piping at not less than 200 psi for two (2) hours per NFPA 13, Section 8-2.2.

3.2 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, downstream of the valve.

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. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

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. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

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

## 3.3 INSTALLATION, SPRINKLERS

A. Sprinklers located in locations where they are likely to be damaged shall be furnished with wire guards.

B. Sprinklers located in showers, wet areas, or subject to corrosion shall be furnished with a corrosion resistant wax coating over polyester coated sprinkler.

C. Sprinklers located beneath open grating shall be furnished with shields.

D. Temperature range and response time shall be suitable for the location and the expected heat release.

E. Within a space all sprinklers should be the same Temperature Range and Response Time to avoid “skipping”.

## 3.4 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. 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.

## 3.5 PIPING SCHEDULE:

A. General Requirements:
1. Comply with requirements of this section for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
2. Manufacturers:
a. Anvil International, Inc.
b. Tyco Fire & Building Products
c. Victaulic Company

B. The following types of fittings are prohibited: plain end couplings and fittings, saddle/mechanical/clamp branch tee, grooved flange rings, and grooved reducing couplings.

C. Size: 2-1/2" and larger above grade.
   1. Pipe: Schedule 40 steel.
   2. Fittings: Butt-welded, groove-end, forged steel flanges, thread-o-let, weld-o-let.
   3. Joints: Butt welded, groove-end couplings, flanged.

D. Size: 2" and smaller above grade.
   1. Pipe: Schedule 40.
   2. Fitting: Cast iron.
   3. Joints: Screwed, groove-end.

END OF SECTION 21 00 30

# SECTION 21 00 40 – DRY-PIPE SPRINKLER SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Steel Pipe and Fittings
   2. Sprinkler heads
   3. Dry pipe sprinkler system
   4. Air compressor

B. Related Requirements:
   1. Section 21 00 00 FIRE PROTECTION SYSTEMS

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 STEEL PIPE AND FITTINGS

A. General Requirements:
   1. Comply with requirements of this section for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
   2. Manufacturers:
      a. Anvil International, Inc.

b. Tyco Fire & Building Products
c. Victaulic Company

B. Standard-Weight Schedule 40 Steel Pipe: stainless steel pipe, ASTM A53/A53M, Type E Grade B. Pipe ends may be factory or field formed to match joining method.

C. Steel Pipe Nipples: stainless steel, ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe.

D. Cast-Iron Flanges: ASME 16.1, Class 125.

E. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
1. Pipe-Flange Gasket Materials: [AWWA C110, rubber, flat face, 1/8 inch thick
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.

F. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. <u>The following types of fittings are prohibited</u>: plain end couplings and fittings, saddle/mechanical/clamp branch tee, grooved flange rings, and grooved reducing couplings.

## 2.3 SPRINKLER HEADS

A. General Requirements:
1. Sprinkler heads shall be UL listed and FM approved.
2. Type: Quick response, liquid in glass bulb.
3. Minimum Pressure: 175 psi
4. Minimum orifice: ½ inch, ½” inch NPT
5. Minimum K-factor: 5.65
6. Sprinklers with orifice larger than ½ inch shall be ¾ inch NPT.

B. Concealed Sprinklers:
1. Cover plate: Viking Bronze or custom color match, if not available, confirmed by the Architect during shop drawings.
2. Manufacturer:
a. Tyco model DS-C
b. Reliable G5-56
c. Viking
3. Head extensions to be provided as required to minimize trapped water in the leg drop.

## 2.4 DRY PIPE VALVE

A. General Requirements:
1. Furnish and install dry pipe valve(s) as indicated on the plans.
2. Standard: UL 260 and FM approved.

3. Pressure Rating: 175 psig minimum.
4. Body Material: Ductile Iron
5. Body Type: Clapper
6. Includes: all trim, including but not limited to: priming cup, fill valve, priming test valve, electric alarm switch, alarm test valve, air control valve, air relief valve, main drain valve, and pressure gauges
7. Manufacturer:
   a. Viking
   b. Tyco
   c. Reliable

2.5 CHECK VALVE

A. General Requirements:
   1. Standard: UL and FM approved for use on fire protection systems.
   2. Pressure Rating: 250 psig minimum.
   3. Body: Ductile Iron
   4. Seat: Brass
   5. Clapper: Rubber faced assembly hinged wo a removable access cover.
   6. Removable access cover.
   7. Manufacturer:
      a. Viking model F-1 Easy Riser Check Valve
      b. Tyco model CV-1F
      c. Reliable

2.6 ALARM PRESSURE SWITCH

A. General Requirements:
   1. Enclosure Standard: UL and FM approved for application in which it is used.
   2. Compatibility: Switch shall be compatible with system devices.
   3. Wiring: Ability to be wired for Class A or Class B Service.
   4. Manufacturer:
      a. Potter PS-10.
      b. Approved equal.

2.7 AIR MAINTENANCE DEVICE

A. General Requirements:
   1. Standard: UL and FM approved.
   2. Bypass: 1/4 inch air supply with field adjustable air pressure regulator with built in ball check valve.
   3. Accessories:
      a. Strainer
      b. Pressure Regulator
      c. Isolation Valves on each side.
   4. Factory Pressure: 40 PSI
   5. Manufacturer:
      a. Tyco AMD

b. Viking Model D-2

## 2.8 AIR COMPRESSOR

A. General Systems:
1. Capacity: Appropriately sized for system volume
2. Type: belt driven, single stage, air cooled with replaceable steel valves.
3. Power:
   a. Less then 3/4 HP shall be 120 volt
   b. 3/4 HP and above shall be 3 phase of suitable voltage available in the building.
4. Manufacturer:
   a. Viking
   b. Or approved equal.

B. UL 2125 Approved Systems:
1. Capacity: 150 gallons or less
2. Compressor: Riser mounted, electric motor-driven, air-cooled, single-stage, oil-less
3. Motor: 1/4 horsepower
4. Production: 1.5 SCFM at 50 PSI
5. Field Adjustable Pressure Range: 14 to 60 PSI.
6. Accessories on Discharge Piping:
   a. Pressure relieve valves with factory setting of 65 PSI.
   b. 1/4 inch check valve
7. Manufacturer:
   a. Viking Model G-1
   b. Or approved equal.

# PART 3 - EXECUTION

## 3.1 INSTALLATION OF PIPING

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

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.
2. 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 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 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 "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

F. Install sprinkler piping with drains for complete system drainage.

G. Connect compressed-air supply to dry-pipe sprinkler piping.

H. Connect air compressor to the following piping and wiring:

1. Pressure gauges and controls.
2. Electrical power system.
3. Fire-alarm devices, including low-pressure alarm.

I. Install alarm devices in piping systems.

J. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13.

K. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than 1/4 inch and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

L. Drain dry-pipe sprinkler piping.

M. Pressurize and check dry-pipe sprinkler system piping, air-pressure maintenance devices, and air compressors.

## 3.2 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 flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having 2-1/2 inch and larger end connections.

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. 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.

F. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

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

## 3.3 INSTALLATION OF VALVES AND SPECIALTIES

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 dry-pipe valves with trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.

a. Install air compressor and compressed-air-supply piping.
b. Install air-pressure maintenance device with shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure.
c. Install compressed-air-supply piping from building's compressed-air piping system.

## 3.4 INSTALLATION, SPRINKLER HEADS

A. Sprinklers located in wet areas, or subject to corrosion shall be furnished with a corrosion resistant wax coating over polyester coated sprinkler.

B. Temperature range and response time shall be suitable for the location and the expected heat release.

C. Within a space all sprinklers should be the same Temperature Range and Response Time to avoid “skipping”.

D. Sprinklers shall be of types indicated in the contract documents.

E. Sprinkler selection shall be such to facilitate complete system drainage if charged.

F. Water sitting in sprinklers drops is not permissible.

## 3.5 INSTALLATION, DRY PIPE VALVE

A. Furnish and install at the interface from the water supply to the dry pipe sprinkler system a dry pipe valve.

B. Dry pipe valve shall be capable of maintaining the system prime while the system remains pressurized.

C. Dry pipe valve shall be provided with contacts for monitoring both high and low air pressures.

D. Dry pipe valve shall be installed in the vertical position with air/priming water above the valve and system water below the valve.

E. Where required by system volume or system response time furnish and install an accelerator.

F. All dry systems, regardless of volume, shall deliver sustained water flow to Inspector's Test Connection within 60 seconds.

## 3.6 INSTALLATION, CHECK VALVE

A. The sprinkler riser check valves shall be manufactured with supply side and system side gauge connections and a main drain outlet in conformance with NFPA 13, Standard for Installation of Sprinkler Systems.

B. The check valves shall be equipped with a removable access cover for periodic inspection as required in NFPA 25, Standard for Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.

## 3.7 INSTALLATION, LOW PRESSURE ALARM SWITCH

A. A supervisory air pressure shall be maintained.

B. A low air pressure alarm shall activate by way of a pressure supervisory alarm pressure switch.

## 3.8 INSTALLATION, AIR MAINTENANCE DEVICE

A. Air supplies provided for sprinkler systems shall be equipped with an automatic air pressure maintenance device.

B. A bypass shall be provided to eliminate air loss when system is in service.

## 3.9 INSTALLATION, AIR COMPRESSOR

A. Furnish and install an appropriately sized air compressor for the system volume.

B. Contractor shall confirm necessary approval requirements with owner.

C. All electrical power requirements for the air compressor shall be the responsibility of this section of the specification (refer to Division 26 drawings for riser diagrams and panel schedules for locations of obtaining power).

D. As soon as the Contractor knows what the power requirements are for the air compressor and where its installed location will be, the Contractor shall inform the Architect/Engineer in writing his intentions for obtaining power.

E. From the air compressor connection to the dry pipe valve, furnish and install an air maintenance device consisting of a strainer and pressure regulator with isolation valves on each side, and a maintenance bypass with a service valve.

F. Discharge piping shall include a check valve to prevent system air pressure loss.

## 3.10 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. 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.

## 3.11 PIPING SCHEDULE

A. General Requirements:

1. Comply with requirements of this section for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
2. Manufacturers:
   a. Anvil International, Inc.
   b. Tyco Fire & Building Products
   c. Victaulic Company

B. <u>The following types of fittings are prohibited</u>: plain end couplings and fittings, saddle/mechanical/clamp branch tee, grooved flange rings, and grooved reducing couplings.

C. Size: 2-1/2” and larger above grade.
1. Pipe: Schedule 10 Steel, “listed” lightweight steel with a minimum UL Corrosion Resistance Ratio of 1.0, or Schedule 40 steel at the Contractor's option.
2. Fittings: Butt-welded, groove-end, forged steel flanges, thread-o-let, weld-o-let.
3. Joints: Butt welded, groove-end couplings, flanged.

D. Size: 2” and smaller above grade.
1. Pipe: Schedule 40.
2. Fitting: Cast iron.
3. Joints: Screwed, groove-end.

END OF SECTION 21 00 40

# SECTION 22 00 00 – PLUMBING WORK

## 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. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 22 of these Specifications.
  1. Section 22 10 00 – Plumbing Piping Systems
  2. Section 22 40 00 – Plumbing Fixtures
  3. Section 22 50 00 – Plumbing Equipment
  4. Section 22 80 00 – Plumbing Specialties

C. The following sections of the Specifications apply to Work under this Section
  1. Division 20 - Basic Mechanical, Plumbing, and Fire Protection
  2. Division 25 - Temperature Control (for monitoring domestic water temperature)

### 1.2 SUMMARY

A. Section Includes:
  1. Sanitary waste system, including but not limited to, sanitary piping, vent piping, acid waste, acid vent piping, plumbing fixtures, floor drains, and cleanouts.
  2. Storm water drainage system, including but not limited to, storm water piping, roof drains, overflow drains, area drains, deck drains, subsoil drain, sump pump, and cleanouts.
  3. Potable domestic water system, including but not limited to, backflow preventers, pressure regulators, water meter, cold water piping, hot water piping, hot water return piping, and connection to all plumbing fixtures, equipment or specialties.
  4. Domestic hot water system, including but not limited to, gas fired/electric hot water heater, storage tank, circulator pump, and expansion tank. Refer to Division 23 for heat exchanger scope.
  5. Valved branches in the potable domestic water system with backflow preventers for extension under other sections of the specification for make-up water usage.
  6. Contractor shall coordinate his work with the work of other trades, and with the architectural and structural drawings.
  7. Draining, filling, and venting of all modified systems as required for the above work. This includes scheduling shutdowns with the Owner. (Refer to Section 20 10 50).
  8. Smoke stopping of all penetrations of pipes and firestopping of the same through fire rated partitions as shown on the architectural drawings including, but not limited to stairways, shafts, corridors, floors, roofs, and required exits. (Refer to Section 20 10 40).
  9. Cleaning and pressure testing equipment, piping, and accessories installed under this section of the specification. (Refer to Section 20 10 00).
  10. All seismic restraints for the above work. (Refer to Section 20 05 48).
  11. Installing accessories specified under other sections of the specification referenced in Related Documents.

## 1.3 REFERENCES

A. Applicable requirements of the current and accepted edition of the following industry standards, codes and specifications shall apply to the Work for Division 22
   1. ANSI American National Standards Institute
   2. ASME American Society of Mechanical Engineers
   3. ASSE American Society of Sanitary Engineers
   4. CISPI Cast Iron Soil Pipe Institution
   5. NSF National Sanitation Foundation
   6. NIOSH National Institute of Occupational Safety and Health
   7. OSHA Occupational Safety and Health Act
   8. UL Underwriters Laboratory, Inc.

## 1.4 QUALITY ASSURANCE

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20.

B. The plumbing system shall comply with the 2011 Reduction of Lead in Drinking Water Act. Components shall be “lead free” equivalent of model number specified regardless if manufacturer’s prefix and suffix have been included.

C. All operable devices and features of plumbing fixtures, accessories, equipment and specialties provided for in the Scope of Work of this Section shall be operated and proved to function satisfactorily for a period of eight (8) hours. Adjust, balance, lubricate as required, and instruct the Owner in the proper operation and maintenance of each device.

D. Plumbing fixtures, equipment and specialties shall be protected against damage in the period between installation and acceptance. Any item damaged shall be removed, repaired and/or replaced at no additional compensation.

E. Protect drains during entire construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

F. Place plugs in the ends of uncompleted piping at the end of each day or when work stops.

## 1.5 ACTION SUBMITTALS

A. Contractor shall submit coordination drawings to the Engineer for review prior to any fabrication or installation. (Refer to Section 20 10 00).

B. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

C. Refer to Division 1, Division 20, and each section of Division 22.

1.6 INFORMATIONAL SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 22.

1.7 CLOSEOUT SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 22.

B. As-built drawings of underground plumbing shall include dimensions from walls/columns and invert elevations.

C. At the completion of the project, submit a letter stating all materials are asbestos free, and meet the specified ASTM E-84 flame/smoke rating of 25/50, and that all piping and duct penetrations are smoke or fire stopped as required by the Code.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 22 00 00

## SECTION 22 08 00: COMMISSIONING OF PLUMBING SYSTEMS

## PART 1 GENERAL

### 1.1 SUMMARY

A. The work under this Section is subject to requirements of the Contract Documents including the Owner's General Conditions and articles of the Construction Manager's General Conditions.

B. General commissioning requirements are detailed in Division 01.

C. The commissioning process does not reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product in accordance with the Contract Documents.

D. This section shall in no way diminish the responsibility of the Division 22 Contractors, Subs and Suppliers in performing all aspects of work and testing as outlined in the contract documents. Any requirements outlined in this section are in addition to requirements outlined in Division 01 and 22 Specifications.

### 1.2 RELATED DOCUMENTS

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

B. The requirements in this section are in addition to those specifically outlined in:

1. Section 01 91 13 – General Commissioning Requirements

### 1.3 PLUMBING EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. The following equipment and systems shall be commissioned as part of this project. All general references to equipment and systems within this document refer only to those identified below:

1. Domestic Water Heaters
2. Plumbing Fixture Controls
3. Thermostatic Mixing Valve
4. Sump Pump

### 1.4 REFERENCES

A. Refer to Section 01 91 13 for applicable references for work associated with this section.

### 1.5 DEFINITIONS & ABBREVIATIONS

A. Refer to Section 01 91 13 for definitions and abbreviations for terms in this section.

## 1.6 COMMISSIONING TEAM

A. Refer to Section 01 91 13 for commissioning team members.

## 1.7 COMMISSIONING SUBMITTALS

A. Refer to Section 01 91 13 for additional required commissioning submittals.

# PART 2 PRODUCTS

## 2.1 TEST EQUIPMENT

B. Refer to Section 01 91 13 for additional test equipment requirements.

C. If not otherwise specified, the following minimum requirements apply.

1. Temperature sensors and digital thermometers shall have a certified accuracy of 0.5°F and a resolution of ±0.1°F.

2. Pressure sensors shall have an accuracy of ±2.0% of the value range being measured (not full range of meter).

# PART 3 EXECUTION

## 3.1 COMMISSIONING PROCESS OVERVIEW

A. Refer to Section 01 91 13 for an overview of the commissioning process.

## 3.2 ROLES AND RESPONSIBILITIES

A. Refer to Section 01 91 13 for roles and responsibilities of additional team members.

## 3.3 SCHEDULING AND COORDINATION

A. Refer to Section 01 91 13 for scheduling and coordination requirements.

## 3.4 PRE-FUNCTIONAL CHECKLISTS

A. Refer to Section 01 91 13 for PFC requirements.

## 3.5 START-UP AND INITIAL CHECKOUT

A. Refer to Section 01 91 13 for Start-Up and Checkout requirements.

## 3.6 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 13 for FPT requirements.

B. Execution:

1. The PC shall engage equipment manufacturer or other 3rd party to execute testing of water quality or conditioning systems (i.e. water softener, reverse osmosis, etc.).

2. FPTs for water quality or conditioning systems shall include tests/samples upstream and downstream of equipment. Samples and/or testing shall be performed to verify equipment is operating properly and delivering water that meets standards identified in the contract documents. If no specific requirements are indicated in the contract documents, industry standards for the tested system shall be utilized.

3. All costs associated with testing water quality or conditioning systems shall be included in the PC's price for the project.

4. The CxA will witness and document the testing performed by the PC or PC's consultant.

5. If the PC does not properly coordinate and schedule with the CxA as identified in section 01 91 13, costs to repeat testing shall be the responsibility of the PC.

6. All costs to repeat testing due to failure shall be the responsibility of the PC.

## 3.7 NON-CONFORMANCE AND COMMISSIONING ISSUES

A. Refer to Section 01 91 13 for information regarding Non-Conformance and Cx Issues.

## 3.8 OWNER TRAINING

A. The GC/CM is responsible for execution of Owner Training as outlined in section 01 79 00.

**END OF SECTION 22 08 00**

# SECTION 22 10 00 – PLUMBING PIPING SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Sanitary piping
2. Storm piping
3. Domestic water piping
4. Non-potable water piping
5. Subsoil drainage

B. Related Requirements:
1. Section 22 00 00 PLUMBING WORK

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Submit a schedule indicating: System, pressure class, pipe material, fittings, joint type, and pressure test.

### 1.3 INFORMATIONAL SUBMITTAL

A. System purging and disinfecting activities report.

B. Pressure test reports.

C. Field quality-control reports.

### 1.4 QUALITY ASSURANCE

A. Installer Qualifications: Installers are to be certified as having been trained and qualified to install and join piping. Installers of specialty systems shall have a current certification, not greater than one year prior, by pipe/joint manufacturer.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Domestic water piping, tubing, fittings, joints, and appurtenances intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent. Components shall be "lead free" equivalent of model number specified regardless of if manufacturer's prefix and suffix have been included.

B. Provide approved backflow preventers in all branch lines in the domestic water system for connections to non-domestic applications.

C. See Division 20 for piping material specifications.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

A. PIPING MATERIAL SCHEDULE P-1
1. Service:
   a. Storm water drainage (ST), below grade.
   b. Sanitary waste (SAN), and Vent (V), below grade.
   c. Piping within the building perimeter to 5' beyond the building limit.
2. Design:
   a. Pressure: gravity vented.
   b. Temperature: 140 degrees F.
3. Pipe: Service weight cast iron, bell and spigot.
4. Fittings: Cast iron bell and spigot.
5. Joints: Neoprene rubber compression type gasket.

B. PIPING MATERIAL SCHEDULE P-2
1. Service:
   a. Storm water drainage (ST), above grade.
   b. Sanitary waste (SAN) and Vent (V), above grade.
   c. Piping within the building perimeter.
2. Design:
   a. Pressure: gravity vented.
   b. Temperature: 140 degrees F.
3. Pipe: Cast iron soil pipe, no-hub.
4. Fittings: Cast iron, no-hub.
5. Joints: No-hub stainless steel coupling assembly, with neoprene rubber gasket.

C. PIPING MATERIAL SCHEDULE P-3
1. Service:
   a. Domestic water, above grade. Includes cold water (CW), hot water (HW), and hot water circulating (HWC)).
   b. Sump pump discharge piping.
2. Design:

a. Pressure: 100 psig.
b. Temperature: 180 degrees F. max. for hot water only.

3. Pipe: Copper, hard drawn, seamless, type L.
   a. Fittings: Wrought copper, solder ends.
   b. Dielectric Isolation union/union flanges between Fittings: water piping and non-copper connections and at all equipment connections.
4. Flanges: Cast bronze, 125 psi.
5. Joints: 95/5 Solder
6. Valves (refer to Section 20 00 13):
   a. Shut-off/Service:
      1) 3” and smaller Ball valve, bronze body, two piece, full port, stainless steel ball and trim.
      2) 4” and larger Gate valve, Class 125 cast iron body, bolted bonnet, non-rising stem, resilient wedge.
   b. Balancing/Throttling:
      1) All sizes Multi-turn calibrated balance valve
      2) Recirculation (end of runs): Thermostatic recirculation balance valve (refer to Section 22 80 00)
   c. Check Valve:
      1) 3” and smaller Class 125 bronze, horizontal swing, Y-pattern, regrinding type, renewable seat and disc, solder ends.
      2) 4” and larger Class 125-iron body, bolted bonnet, horizontal swing, renewable seat and disc, bronze mounted, flanged ends.
   d. Hose End Valve: Interior: ¾” hose thread outlet x copper sweat inlet with integral vacuum breaker. Nibco figure 63-VB.

D. PIPING MATERIAL SCHEDULE P-4
1. Service:
   a. Domestic cold water (CW), above grade, ½” and smaller for connection from ice maker box/water supply box to ice maker, refrigerator, coffee machine, etc.
2. Design:
   a. Pressure: 100 psig.
   b. Temperature: 180 degrees F. max.
3. Pipe: Copper, annealed, seamless, type L.
   a. Fittings: Rough brass, compression ends.
4. Valves (refer to Section 20 00 13):
   a. Shut-off/Service:
      1) 1/2” and smaller angle or straight stop, depending on installation location.

E. PIPING MATERIAL SCHEDULE P-5
1. Service: Potable water, 2” and smaller, below grade – inside the building.
2. Design: Pressure: 100 psig. Temperature: 150 degrees F.
3. Pipe: Copper, annealed “soft”, seamless, type K.
4. Fittings: Wrought copper, solder ends.
5. Joints: 95-5 solder.

F. PIPING MATERIAL SCHEDULE P-6
1. Service: Subsoil drainage, 3” and larger below grade.
2. Design:
   a. Pressure: gravity vented.
   b. Temperature: 80°F

3. Pipe: Schedule 40 PVC perforated subsoil pipe.
4. Fittings: Schedule 40 PVC DWV.
5. Joints: Solvent.

## 3.2 INSTALLATION OF PIPING

A. The Plans indicate the approximate location and arrangement of roughing-in for waste, vent and domestic water piping to serve the respective plumbing fixture, equipment and specialties. Final locations and arrangements shall be determined from approved shop drawings of the respective item.

B. Install copper tubing in accordance with CDA's "Copper Tube Handbook."

C. Install ductile-iron piping in accordance with AWWA C600 and AWWA M41. Note #1: Provide retainer glands where flanged ductile iron pipe is installed at point of building entry.

D. Install cast-iron piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

E. Install aboveground PVC piping in accordance with ASTM D2665.

F. Install belowground PVC piping in accordance with ASTM D2321.

G. Pressure test each respective piping system for tightness to the test pressure indicated without loss. Repair any leaks and retest, as required. If test pressure is not indicated, hydrostatically test to 1.5 times the system operating pressure.
1. Storm water drainage, sanitary waste and vent, deck drain piping: Pressure test at not less than 15 feet static head of water for two (2) hours minimum.
2. Domestic water inside the building: Hydrostatically pressure test at 150 psi for four (4) hours minimum.
3. Ductile iron domestic water piping outside the building: Hydrostatically pressure test at 200 psi for four (4) hours minimum.
4. CSST gas piping (appliance connector or vented sleeve lab gas): New piping shall be installed, capped, and pressure tested with Nitrogen at 50 psi for two (2) hours. After the piping has passed the above pressure test the final tie-ins shall be made, then the system will be filled with natural gas and the final joints will be checked with soap.

H. Main vents shall be the same size as waste lines and shall extend 12” minimum above the roof. Minimum vent thru the roof (VTR) shall be 3” size.

I. Install all piping with pitch to vent or drain. Provide drain valves at low points and air vents at high points. Drain valves and air vents shall be ¾” bronze, 2 piece body ball valves with ¾” hose end adapter, cap, and chain. In ½” through 2” pipe, contractor may use Webstone model T-drain.

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. 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.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. 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.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions/flange/coupling at final connection to each piece of equipment to allow disconnection of equipment, except where coupling is integral to the equipment (i.e. supply lines to faucets, flush valves, etc.)

R. Install sleeves for piping penetrations of walls, ceilings, and floors.

S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

T. Subsoil drainage: The trenches for the drain tile shall be excavated to allow at least 6” of filler material to be placed in the trench before laying the pipe and a backfill of at least 8” of filter material on both sides. Fill over the pipe shall extend to 18” above the pipe where located around the exterior of the building.
   1. The filler material shall be washed, uniformly graded mixture of crushed stone, or uncrushed gravel, with 100% passing 1” sieve, 90 to 100% passing 3/4” sieve, 15 to 40% passing 5/8” sieve, and 0 to 5% passing No. 4 sieve.
   2. A filler fabric shall be placed in the trench between the earth and filter material and shall completely enclose the filler material. The fabric shall be equal to Mirafi 140N; .5 oz. nonwoven fabric composed of strong rotproof polymeric fibers. The fabric shall be non-biodegradable and resistant to acids and alkali solutions within the pH range of 3 to 12. The fabric shall have the following physical properties.
      a. E.O.S. #80 U.S. Standard Sieve
      b. Water Permeability Coefficient (k): 0.07 cm/sec
      c. Water Flow Rate: 48 ga./min/ft2
      d. Thickness: 30 mils
      e. Burst Strength: 125 psi

U. Provide flexible copper water line of sufficient length to allow servicing and moving of appliance for cleaning without kinking piping.

V. Provide ice maker drain hose of sufficient length to drain into floor sink or floor drain.

## 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 in accordance with 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:

D. Apply appropriate tape or thread compound to external pipe threads.

E. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

G. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings in accordance with ASTM B828 or CDA's "Copper Tube Handbook."

H. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools and procedure recommended by pressure-seal-fitting manufacturer. Leave insertion marks on pipe after assembly.

I. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on joint fittings by inserting tube to measured depth.

J. Extruded-Tee Connections: Form tee in copper tube in accordance with ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

K. Joint Construction for Grooved-End Copper Tubing: Make joints in accordance with 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 per manufacturer’s instructions.

L. 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 in accordance with ASME B31.9.

M. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

N. Hubless, Cast-Iron Soil Piping Coupled Joints:
   1. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

O. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
   1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. PVC Piping: Join in accordance with ASTM D2855 and ASTM D2665 appendixes.

P. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:

Q. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.

R. CPVC Piping: Join in accordance with ASTM D2846/D2846M.

S. PVC Piping: Join in accordance with ASTM D2855.

## 3.4 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 3 and Smaller: Use dielectric waterway plastic lined nipple.

C. Dielectric Fittings for NPS 4 and Larger: Use dielectric flange kits.

## 3.5 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.

## 3.6 FIELD QUALITY CONTROL

A. Pipe cleaning:
   1. All domestic water lines shall be flushed clean at the completion of the Work. Refer to Section 20 10 56 – Cleaning of Piping Systems.
   2. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals.
   3. All drainage lines shall be flushed clean at the completion of the Work. Rod out any obstructions encountered.

END OF SECTION 22 10 00

# SECTION 22 30 00 – DRAINS AND CLEANOUTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Areaway Drains
2. Backwater Valves
3. Cast Iron Downspout Boots
4. Cleanouts
5. Floor Drains
6. Floor Drain Trap Seal
7. Floor Sinks
8. Roof Drains
9. Trench Drains

B. Related Requirements:
1. Section 22 00 00 PLUMBING WORK

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Submit a room-by-room schedule indicating floor drains and cleanouts to be used including top size, shape, floor finish material, and setting height with respect to concrete slabs.

### 1.3 QUALITY ASSURANCE

A. Pre-installation meeting shall review the Contractors measures to ensure elevation of drains with respect to finished floors and squareness of square drains with respect finished walls and flooring.

B. Pre-installation meeting shall review the installation of the roof drain, roof insulation and roofing waterproofing.

## PART 2 - PRODUCTS

### 2.1 BACKWATER VALVES

A. Backwater valves installed in piping shall be cast iron body. ANSI B16.1 class 125 lb. flanged ends, with fabricated elastomer "duckbill" check sleeve. Flanged backwater valves shall be Red Valve Co., Series 39.

B. Backwater valves installed at the point of discharge in sewer manholes shall be slip-on fabricated elastomer “duckbill” check sleeve. Backwater valve shall slip over pipe outside diameter and clamp on the pipe with stainless steel clamps. Slip-on backwater valves shall be Red Valve Co., Series TF-2.

## 2.2 CLEANOUTS

A. (FCO) interior finished floor:
1. Cast iron body, threaded adjustable housing, flanged ferrule with straight tread gasketed bronze plug.
2. Square secured satin nickel bronze scoriated top.
3. Vandal proof fasteners
4. Tops shall be for tile, carpet, ceramic tile, terrazzo tile as required.
5. Josam 55000-1-SQ-22-VP, , J.R. Smith 4041-U, MIFAB C1100-S-1-6, Sioux Chief 834-4DNQV, Wade W-8000-S-75-VP, Watts CO-200-S-6, or Zurn ZN-1400-T-BP-VP.

B. (FCO) interior unfinished floor:
1. Cast iron body, threaded adjustable housing, flanged ferrule with straight tread gasketed plug.
2. Round secured satin nickel bronze scoriated top.
3. Vandal proof fasteners.
4. Josam 55000-1-22-VP, J.R. Smith 4021-U, MIFAB C1100-R-1-6, Sioux Chief 834-4DNRV, Wade W-8000-1-75-VP, Watts CO-200-R-6M or Zurn Z-1400-BP-VP.

C. (WCO) wall type for concealed riser in finished spaces:
1. Provide cleanout fitting with screwed plug opening and countersunk bronze plug.
2. Provide 8” x 8” square access covers with polished nickel bronze beveled edge frame with anchor lugs for over the wall installation.
   a. Smooth stainless steel cover.
   b. Vandal proof fasteners.
3. J.R. Smith 4730-U-NB, MIFAB C1460-S-3-6, Wade 8303-85-75-VP, Watts CO-300_S-6, Zurn ZANB-1460-9-VP, or approved equivalent.

D. (WCO) wall type for concealed riser in unfinished spaces:
1. Provide cleanout fitting with screwed plug opening and countersunk bronze plug.
2. Provide round access covers.
   a. Smooth stainless steel cover.
   b. Vandal proof center screw.
3. Josam, J.R. Smith, MIFAB, Sioux Chief, Wade, Watts, Zurn, Josam, or approved equivalent.

E. (YCO) exterior location:
1. Cast iron body, threaded adjustable housing, flanged ferrule with straight tread gasketed plug.
2. Round secured cast iron or ductile iron top.
3. Josam 55000-22-VP, J.R. Smith 4221-U, MIFAB C1100-XR-4-6, Sioux Chief 834-4DiRV, Wade W-8000-12-75-BP, Watts CO-200-RX-4, or Zurn Z-1400-BP-VP.

## 2.3 FLOOR DRAINS

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency. Where trap primers are indicated on the drawings, the appropriate option shall be provided on the respective drain.

B. Floor Drain: interior finished floor (FD-A):
   1. Cast iron body with flashing flange and seepage openings.
   2. 6” x 6” square adjustable satin nickel bronze strainer top.
   3. Vandal proof fasteners.
   4. 3” outlet.
   5. Wade W-1103-G6-1-VP, Watts FD-100-M6-6, Zurn ZN-415-6S-VP, J.R. Smith 2005-B06NB-U, MIFAB F1100-S6-1-6, Sioux Chief 832-235NQV, or Josam 30000-6S-VP.

C. Floor Drain: mechanical equipment room (FD-B):
   1. Cast iron body with flashing flange and seepage openings.
   2. 7” cast iron loose set tractor strainer.
   3. 3” outlet.
   4. Wade W-1103-TS7-12, Watts FD-300-6, Zurn Z-415-7N, J.R. Smith 2000-D-CI, MIFAB F1100C-7N, Sioux Chief 833-23DiR, or Josam 30000 7E-93.

D. Floor Drain: interior unfinished floor (FD-C):
   1. Cast iron body with flashing flange and seepage openings.
   2. 6” round adjustable satin bronze round strainer top, with vandal proof fasteners and 3” outlet. Wade W-1100-A6-VP, Watts FD-100-A-6, Zurn ZN-415-6B-VP, J.R. Smith 2000-A06NB-U, MIFAB F1340-Y-Q-1-6, Sioux Chief 833-235DNRV or Josam 30000-6A-VP.

## 2.4 FLOOR DRAIN TRAP SEAL

A. Smooth, soft, flexible, elastomeric PVC material, open on top with closure at bottom. Allows wastewater to open and adequately discharge floor drain through its

B. Interior. Closes and returns to original molded shape after wastewater discharge is

C. Complete. Complies with ASSE 1072. Precsion Plumbing Products Pro-Drain Trap Seal, ProSet Trap Guard, Rectorseal SureSeal, MIFAB MI-GUARD or approved equivalent.

## 2.5 FLOOR SINKS

A. Floor Sink (FS-A):
   1. Cast iron 12” square floor sink with 8” sump.
   2. A.R.E. interior aluminum dome strainer.
   3. Nickel bronze hinged top.
   4. Wade W-9140, Zurn ZN-1901-K, J.R. Smith 3150, MIFAB FS1730-1, or Josam 49340A-LF-NB.
   5. Provide 16 gauge galvanized steel protective cover, painted safety orange, with protection to not scratch sink enamel for protection of sink during construction.
   6. Where pipes receive drainage terminations, provide a factory ½ or ¾ grate as appropriate.

2.6 ROOF DRAINS

A. Roof Drain: (RD-A):
1. Cast iron body with flange, flashing collar and gravel stop.
2. Removable cast iron dome
3. Under deck clamp.
4. Sump receiver pan.
5. Adjustable extension. Provide extension, as required, to suit thickness of roof construction.
6. Wade W-3000-AE-42-52-53, Watts RD-300-B-D-K, J.R. Smith 1015-R-C-CID, MIFAB R1200-EU-B-M-U, Josam 21500-AE-1-2-22, or high performance roof drain with funnel-shaped body: Zurn Z-100-C-EA-R.

B. Overflow Drain: (OD-A):
1. Cast iron body with flange, flashing collar and gravel stop.
2. Removable cast iron dome
3. Under deck clamp.
4. Sump receiver pan.
5. Adjustable extension. Provide extension, as required, to suit thickness of roof construction.
6. 2" high dam.
7. Wade W-3000-AE-D-42-52-53, Watts RD-300-B-D-K-R, Zurn ZC-100-C-EA-R-89. J.R. Smith 1045-R-C-CID, MIFAB R1200-EU-B-M-U-W2, or Josam 21500-16-AE-3-22.

C. Overflow Drain Nozzle (OFN-A):
1. Overflow drain downspout cover to be located at each discharge location.
2. Downspout cover shall be fabricated of 304 stainless steel and provide with hinged perforated cover and vandal proof construction.
3. Josam 25020-Z-VP, J.R. Smith 1775-U, MIFAB R1960, Wade 3941-VP, Watts RD-950-6, Zurn Z199-DC-VP or approved equal.

2.7 TRENCH DRAIN

A. Trench Drain – Continuous Channel: (TD-A):
1. 6" wide, modular 16-gauge stainless steel drainage system.
2. Class C duty stainless steel slotted grate.
3. Manufacturer's standard device for securing grates to channel section. Zurn Z890, JR Smith 9660, or approved equivalent

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Drain and cleanout outlets shall be compatible with respective piping material and size. Outlets below grade shall be push type. Outlets above grade may be no-hub or push type at the Contractor’s option. Tops shall be compatible with the flooring system.

B. Square/rectangular drains/cleanout tops shall be set square to the finished room walls. Tops that out of square by greater than 1/8” or produce an irregular floor title shall be corrected. Contractor’s options to install with round block-outs during the concrete floor pour to allow subsequent adjustment.

C. Provide full size cleanouts up to 4” size above the lowest floor line in all drainage risers, and where total of the fittings exceed 120 degrees and at changes in direction greater than 45 degrees in horizontal drainage lines, and at intervals of not greater than fifty (50) feet in straight piping runs 4” diameter and smaller, and one hundred (100) feet for piping over 4” diameter.

D. Do not install cleanouts in electrical equipment rooms. Extend the cleanout to outside the room limits.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Where cleanout or drain is located in open ground, extend the cleanout to finished grade elevation and install a 16” x 16” x 8” deep concrete pad at grade to secure the cleanout.

G. Provide deep seal P-traps for all floor drains.

H. Any drain body set prior to approval shall be performed with block-outs to allow correct tops and finished heights to be adjusted.

I. Install floor drains, floor sinks and shower drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.

J. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

K. Install roof drains in accordance with roof membrane manufacturer's written installation instructions at low points of roof areas.
   1. Install flashing collar or flange of roof drain to 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.

L. Install downspout nozzles at exposed bottom of conductors where they spill onto grade.

M. Install horizontal backwater valves in floor with cover flush with floor.

## 3.2 PROTECTION

A. Protect drains during 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.

## 3.3 CLEANING

A. Drain and cleanout tops shall be clean in as new condition free of concrete, grout, floor glue, tape, or tape residue.

END OF SECTION 22 30 00

# SECTION 22 40 00 – PLUMBING FIXTURES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Water closets
2. Water closet seats
3. Water closet flush valves
4. Water closet carriers
5. Urinals
6. Urinal flush valves
7. Urinal carriers
8. Lavatories
9. Lavatory faucets
10. Lavatory accessories
11. Sinks
12. Sink Accessories
13. Sink faucets
14. Mop Sink Basin
15. Electric water coolers
16. Drinking fountains
17. Emergency eye/face wash

B. Related Requirements:
1. Section 22 00 00 PLUMBING WORK

C. Furnish and install the following plumbing fixtures where shown on the Plans and as hereinafter specified. Plumbing fixtures shall be institutional/commercial grade fixtures, no residential or “trade” grade fixtures are acceptable. Plumbing fixtures and accessories shall have all options, body material, water consumption, and accessories as specified where or not listed as a prefix, suffix, or catalog number. Include all necessary work in the related sections of the Specifications (subsection 22 00 03) and accessories to provide for complete installation and operation of the respective fixture.

D. All plumbing fixtures and non-metal accessories shall be white color, except where shown or specified otherwise.

E. Vitreous china fixtures, where specified, shall be best quality, non-absorbent. Warped or imperfect fixtures shall not be accepted. Enameled cast iron fixtures, where specified, shall be thoroughly fused and bonded to body without discoloration, chips, flaws or cracks. Finish all exposed surfaces.

F. Fixture trim shall be cast brass with polished chrome-plated finish on exposed surfaces, except where shown or specified otherwise.

G. Fixture traps shall be tubular wall type, minimum 17 gauge with integral cleanout plugs, polished chrome plated finish, except where shown or specified otherwise. Size to suit fixture tailpiece. Comply with local plumbing code.

H. All water closets, and urinals shall be from the same manufacturer. All faucets for lavatories, janitor sinks, and sinks shall be from the same manufacturer. All supplies and stops for lavatories and sinks shall be from the same manufacturer. All fixture carrier shall be from the same manufacturer.

I. Furnish accessories for fixtures requiring trim, carriers, brackets, back-up plates, specialties, etc. for respective complete installation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. ASME A112.19.2/CSA B45.1 - Ceramic Plumbing Fixtures

C. ASME A112.19.5-2022/CSA B45.15:22 Flush valves and spuds for water closets, urinals, and tanks

D. ASME A112.19.3-2022/CSA B45.4:22 Stainless steel plumbing fixtures

2.2 MANUFACTURERS

A. Vitreous China Fixtures: American Standard, Kohler, Mansfield, Zurn, Sloan, Toto

B. Stainless Steel Sinks: Elkay, Acorn, Advance Tabco, Ameteko Wasserstrom, Franke, Just.

C. Carriers: Josam, J.R. Smith, MIFAB, Wade, Watts, Zurn

D. Flush Valve: Sloan, AMTC, American Standard, Zurn

E. Supplies, Strainer, Traps: McGuire, Chicago Faucets, Dearborn, Brass Craft, Engineered Brass, American Standard, Kohler, Elkay.

F. Faucets: Chicago Faucets, no substitutions allowed

## 2.3 WATER CLOSETS

A. Wall hung (WC-A & WC-B):
1. Vitreous china elongated bowl, 1.28-1.6 gal/flush.
2. Siphon-jet.
3. wall-mounted with 1-1/2” (top) inlet spud.
4. High Efficiency Toilet (HET).
5. Conforms to ASME Standard A112.19.2 fixture dimensions.
6. American Standard “AFWALL Millennium FloWise” model 2257.101, Kohler “Kingston” model K-84325-0, Mansfield “Erie” model 1301, Sloan model ST-2459, Toto CT708E, or Zurn model Z5615-BWL. Mount at ADA height where scheduled on drawings.

B. Floor mounted (WC-C):
1. Vitreous china elongated bowl, 1.28-1.6 gal/flush.
2. Siphon-jet, floor mounted 17” rim height, with 1-1/2” top inlet spud.
3. High Efficiency Toilet (HET).
4. Conforms to ASME Standard A112.19.2 fixture dimensions, ADA, and ICC 117-1.
5. American Standard “Madera FloWise” model 3043.001, Kohler “Highcliff” model K-96057-0, Mansfield “Adriatic” model 1319, Sloan model ST-2029, Toto CT705ELN or Zurn model Z5665-BWL.

## 2.4 WATER CLOSET SEATS

A. Provide seats for each water closet furnished.

B. Standard Seat:
1. Heavy duty commercial, solid plastic, open front less cover for elongated bowl.
2. Integral bumpers.
3. Self-sustain hinges and external check hinges with stainless steel hinge pins and mounting bolts.
4. American Standard model 5901.100SS, Bemis model 1955SSCT, Church model 295SSCT, or Zurn model Z5955SS-EL-STS.

## 2.5 WATER CLOSET: FLUSH VALVES

A. Provide flush valves for each water closet furnished, as scheduled.

B. Automatic, Battery Powered, 1.28 GPF:
1. Diaphragm type, 1.28 gallons per flush closet flushometer.

2. ADA compliant, battery powered automatic “no hands” operation.
3. Chrome plated infrared sensor housing, angled sensor window.
4. Manual override flush button.
5. 1” I.P.S. screwdriver angle stop with vandal resistant stop cap.
6. Adjustable tailpiece.
7. Vacuum breaker flush connection, spud coupling and spud flange for 1½” top spud.
8. Valve shall be in compliance with the applicable sections of ANSI/ASME A112.19.2. Sloan model Optima SMO 111-SMO-1.28, AMTC AEF-801-CT-12, American Standard 6147SM121.002, or Zurn model ZER6000PL-HET-CPM.
9. Sloan model G2 Optima Plus 8111-1.28, no substitutions.

## 2.6 WATER CLOSET: CARRIERS

A. Carrier:
1. Adjustable anchor foot type for above-the-floor no-hub piping connection for wall hung toilet.
2. Cast iron factory painted adjustable faceplate with corrosion-resistant adjustable waste coupling with neoprene seal and integral test cap.
3. Zinc plated steel fixture studs with vandal proof chrome plated fixture cap nuts and fiber fixture washers.
4. Josam 12674/12684/12694-VP, J.R. Smith series 0200, MIFAB series MC-10, Wade series W-311, Watts series ISCA-101, or Zurn series Z-1203-N-VP.
5. Arrangements shall be per the application.

## 2.7 URINALS

A. Urinal (U-A):
1. Vitreous china water saver siphon-jet, wall hung and with ¾” (top) inlet spud.
2. 2”IPS female threaded outlet (rear) connection and wall hanger.
3. Conforms to ASME Standard A112.19.2 fixture dimensions.
4. American Standard “Trimbrook”, model 6561.017, Kohler “Freshman” model K-4989-T, or Zurn Z5730.

## 2.8 URINAL: FLUSH VALVES

A. Provide flush valve for each urinal furnished.

B. Automatic, Battery Powered, 1.0 GPF:
1. Diaphragm type, 1.0 gallons per flush urinal flushometer.
2. Battery powered automatic “no hands” operation, chrome plated infrared sensor housing, angled sensor window.
3. Manual override flush button.
4. ¾” I.P.S. screwdriver angle stop with vandal resistant stop cap.
5. Adjustable tailpiece.
6. Vacuum breaker flush connection, spud coupling and spud flange for ¾” top spud.
7. Valve shall be in compliance with the applicable sections of ANSI/ASME A112.19.2.
8. Valve to be actuated by 6VDC solenoid.

9. Sloan model G2 Optima Plus 8186-1.0 (Top Mounted), AMTC AEF-801-CU-10 (Top Mounted)
10. Sloan model EBV500A, American Standard 6145SM101.002, or Zurn model ZR6003AV-WS1-VP (Side Mounted).
11. Sloan “G2 Optima Plus” model 8186-1.0, no substitutions.

## 2.9 URINAL CARRIER

A. Carrier:
   1. Adjustable height universal plate hanger carrier with rectangular steel uprights
   2. Block base anchor feet, upper and lower support plates, and vandal proof cap nuts.
   3. Josam 17550-UR, J.R. Smith 0636, MIFAB MC-32, Wade W-401-AM1-M3, Watts CA-321, or Zurn model Z1222-58.

## 2.10 LAVATORIES

A. Undercounter Lavatory (L-A):
   1. Nonporous acrylic-polyester.
   2. Nominal size: 18-1/8” x 14-3/4” with oval shaped bowl.
   3. Conforms to ASME Standard A112.19.2 for fixture dimensions.
   4. Corian Design model 810P.

B. Wall Hung Lavatory (L-B):
   1. Vitreous china with front overflow, faucet ledge, concealed carrier arms, self-draining deck area with contoured back and side splash shields.
   2. Nominal size: 20-1/2” x 18-1/4” with “D” shaped bowl.
   3. Single Faucet hole.
   4. Conforms to ASME Standard A112.19.2 for fixture dimensions.
   5. American Standard model “LUCERNE” 0356.015, Kohler “Kingston” model K-2006-0, Mansfield “Grand Isle” 2018HBNS-8, Sloan model SS-3803, or Zurn model Z5348.

## 2.11 LAVATORY FAUCETS

A. Automatic, Battery powered:
   1. Single hole.
   2. 5-½” spout.
   3. Single supply for tempered water.
   4. Vandal proof 0.5 GPM non-aerating spray outlet.
   5. Infrared sensor operated, metal jacketed battery powered automatic faucet.
   6. Thermostatic temperature mixing valve
   7. Chicago Faucets model 116.201.AB.1T

## 2.12 LAVATORY ACCESSORIES

A. Standard Strainer: 1-1/4” x 17 gauge cast brass grid strainer, integral spud and tailpiece.

1. McGuire Mfg. model 155A, Dearborn Brass model 760-1, Just J-15-FS, or approved equivalent.

B. Wheelchair Lavatory Strainer: 1-1/4" x 5" offset x 17 gauge cast brass grid strainer, integral spud and tailpiece.
   1. McGuire Mfg. model 155WC, Dearborn Brass model 760W-1, Just J-ADA-15-FS, or approved equivalent.

C. Supplies: Loose keyed ball valve angle stops with lock shield caps and ½" (nominal) copper solder (5/8" ODS) inlet x 3/8" OD outlet x 12" long flexible risers.
   1. Provide cast brass escutcheons.
   2. Chicago Faucets model STB-41-11-AB, no substitution

D. Trap: 1-1/2" x 1-1/4" x 17 gauge tubular P-trap with clean-out, plug and wall escutcheon.
   1. McGuire Mfg. model 8902, Dearborn Brass model 510, Just model JT-150, or approved equivalent.

E. Trap primer tailpiece:
   1. 1-1/2" X 17 gauge tubular tail piece, chrome plated polished brass with cleanout with ½" compression fitting for stainless steel braided primer hose. Assembly shall include hose and wall escutcheon.
   2. Trap Primer shall be Dearborn Brass model 832-1, Precision Plumbing Products LTP-500, Zurn Z1021 or equivalent by McGuire or Just.

F. Insulation Kit: Conforms to 28CFR Part 36, Article 4.19.4 (7/26/91).
   1. Truebro model LavGuard2, Dearborn Brass model ADA100, Just model J-ADA-150, or approved equivalent.

G. Themostatic mixing valve: ASSE 1070 compliant thermostatic temperature mixing valve with hot and cold water supply check valves.
   1. Equal to Acorn ST70, Symmons Maxline 8210-CK, or T&S Brass BP-TMV-38C.

H. Standard Wall Hung Carrier:
   1. Adjustable concealed arm lavatory carrier with rectangular steel uprights and block base anchor feet.
   2. Josam 17100, J.R. Smith 700-M31, MIFAB MC-41, Wade model W-520-M36, Watts WCA-411 or Zurn Z1231.

## 2.13 SINKS

A. Single Compartment, Undermount (S-A):
   1. 18 gauge, type 304 stainless steel, self-rim single bowl sink.
   2. Inside bowl dimensions: 12" L x 12" W x 5 ½" D.
   3. Elkay model ELUHAD121255PD, or equivalent by Acorn, Just, Advance Tabco, Amteko Wasserstrom, or Franke.

B. Two Compartment Stainless Steel Sink, Free Standing (S-B):
   1. 16-gauge, type 300 stainless steel, 14" deep bowls welded ¼" radius coved corners, channel rim with full 9" high backsplash, polished finish.
   2. Sink shall be supported by four 1 5/8" tubular, 16-gauge stainless steel legs with bullet feet.

3. (2) 16"x20"x14" bowls, double sided drain boards, (2) faucet drillings.
4. Elkay Model Dependabilt 14-2C16X20-2-18X

## 2.14 SINK ACCESSORIES

A. Strainer: Provide stainless steel crumb basket with rubber stop for 3-1/2" drain opening and 1-1/2" OD brass tailpiece for each sink bowl, that does not have a disposal.
   1. Elkay model No. LK-35, Just J-35, or Advance Tabco K-310.

B. Supplies: Loose keyed ball valve angle stops with lock shield caps and ½" (nominal) copper solder (5/8" ODS) inlet x 3/8" OD outlet x 12" long flexible risers.
   1. Provide cast brass escutcheons.
   2. Chicago Faucets model STB-41-11-AB, no substitution

C. Solids interceptor, where required: See Section 22 80 00.

## 2.15 SINK FAUCETS:

A. Small Gooseneck, Wrist blade handles:
   1. Polished chrome.
   2. 8" centers.
   3. 5-1/4" swing gooseneck spout.
   4. Vandal proof 1.5 GPM non-aerating spray outlet.
   5. Vandal proof metal wrist blade handles.
   6. Complies with ANSI A112.18.1.
   7. Chicago Faucets model 786-GN2FCXKABCP

B. Wall Mounted Double-Jointed:
   1. Polished chrome.
   2. Adjustable center 4" to 8-3/8", H supply arms.
   3. 13" double jointed swing spout.
   4. 2.5 GPM aerator.
   5. Metal lever handles.
   6. Complies with ANSI A112.18.1.
   7. Chicago Faucets model 445-D222213AB

## 2.16 MOP SINK BASIN: (MSB):

A. Receptor (basin):
   1. 24" x 24" x 12" high, precast terrazzo one-piece basin, ground smooth, grouted and sealed to resist stains.
   2. Top edge capped with 20-gauge type 302 stainless steel cast integrally on all four sides.
   3. corn model TSH-24-SSC-KH36-KWG, Fiat model TSB-100, or Stern Williams model "SERVICEPTOR" SB-900.

B. Faucet:

1. Polished chrome.
2. Vacuum breaker rigid spout with ¾” hose thread outlet.
3. Wall brace and pail hook.
4. ½” F union inlets on exposed valves on 6” centers.
5. Lever handles, indexed and tabbed for “HOT” and “COLD”.
6. Chicago Faucets model 835 for overhead supplies. Chicago Faucets model 897-RCF for supplies thru-the-wall.
7. Provide cold water hose bibb (HB-A) with RPZ backflow preventer for chemical mixer.
8. Pipe drain from RPZ to sink.

C. Strainer: Cast brass outlet with stainless steel strainer cast integrally into bottom of basin to provide for an inside caulk connection for a 3” waste pipe.

D. Splash Panels: Provide 20 gauge 302 stainless steel sheet splash catcher panels on one or two sides as required.

E. Accessories: Provide 36” hose and hose wall bracket.

2.17 ELECTRIC WATER COOLER: BI-LEVEL, SEMI-RECESSED W/ BOTTLE FILLER (EDF-A):

A. Semi recessed, filtered, refrigerated, bi-level for general public and ADA usage with bottle filling station.
1. Lower unit shall be wheelchair accessible.
2. Bubbler shall be activated by mechanical push-button and have built-in pressure regulator for supply pressure range from 20 to 125 psi.
3. All exposed surfaces shall be satin-finish type 304 stainless steel.
4. Furnish mounting wall box and cover grille.
5. All waterway components shall be copper construction with lead-free connections.
6. Refrigeration system shall be air-cooled; chill the drinking water in a storage tank type heat exchanger; have an adjustable thermostatic control; be rated to cool 8 gph from 80 deg. F to 50 deg. F at 90 deg. F room temperature.
7. Certified by ARI, UL and CSA and comply with all local building codes and ADA Requirements.
8. Elkay model LZWS-LRPBM28K, Halsey Taylor model. HTHBWF-HRFSER, or Oasis model no. M8CREBF.

B. For masonry construction applications, Plumbing Contractor will mount water cooler directly to wall using factory supplied mounting box.

C. For non-masonry applications, provide and mount using Josam 17550-WCBL, J.R. Smith 0830, MIFAB MC-31, Wade W-403-BL-M36, Watts CA-431-1, or Zurn 1225-BL.

2.18 ELECTRIC WATER COOLER: SINGLE LEVEL W/BOTTLE FILLER (EDF-B):

A. Wall mounted, vandal resistant, refrigerated, for general public and ADA usage with bottle filling station.
1. Lower unit shall be wheelchair accessible.

2. Bubbler shall be activated by mechanical push-button and have built-in pressure regulator for supply pressure range from 20 to 125 psi.
3. All exposed surfaces shall be satin-finish type 304 stainless steel.
4. Furnish mounting wall box and cover grille.
5. All waterway components shall be copper construction with lead-free connections.
6. Refrigeration system shall be air-cooled; chill the drinking water in a storage tank type heat exchanger; have an adjustable thermostatic control; be rated to cool 8 gph from 80 deg. F to 50 deg. F at 90 deg. F room temperature.
7. Certified by ARI, UL and CSA and comply with all local building codes and ADA Requirements.
8. Elkay model LZS8WSSP, or equivalent by Halsey Taylor, Murdock.

## 2.19 NON-ELECTRIC DRINKING FOUNTAIN (DF-A):

A. Wall mounted, non-electric, non-refrigerated.
1. Unit shall be wheelchair accessible.
2. Bubbler shall be activated by mechanical push-button and have built-in pressure regulator for supply pressure range from 20 to 125 psi.
3. All exposed surfaces shall be satin-finish type 304 stainless steel.
4. All waterway components shall be copper construction with lead-free connections.
5. Certified by ARI, UL and CSA and comply with all local building codes and ADA Requirements.
6. Elkay model EDFPBM114K or approved equivalent from Halsey, Murdock, or Oasis.

B. For masonry construction applications, Contractor shall mount water cooler directly to wall using factory supplied mounting box.

## 2.20 EMERGENCY EYE/FACE WASH – EXPOSED, FLOOR MOUNTED (EW-A)

A. Combination eye/face wash station shall comply with ANSI Z358.1.
1. 10” diameter ABS plastic or stainless steel eyewash bowl.
2. ½” stay-open ball valve with hand operated paddle push handle.
3. ABS or epoxy coated steel pipe.
4. 3.0 gpm flow control for eye/face wash.
5. Unit shall be floor mounted and wall anchored, barrier-free, accessible.
6. Unit shall be provided with a ASSE 1071 compliant thermostatic mixing valve.
7. Acorn model S0320-BF, Bradley model S19214, Guardian Equipment model GBF1724, Haws model 7261-7271, Speakman SE-490/491, or Stingray S2515-EP.

# 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. Provide stops (valves) in all water supplies to all fixtures.

B. Provide templates of openings required for countertop mounted fixtures to the General Contractor.

C. Connections between plumbing fixture outlets and respective waste piping shall be gas and watertight. Use suitable and approved setting compound or gasket; rubber gaskets or putty are not acceptable.

D. Plumbing Fixture Installation:
   1. Install fixture level and plumb according to roughing-in drawings.
   2. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
   3. Provide carriers or appropriate mounting frame for each wall hung or recessed fixture furnished.

E. Floor Sink Installation:
   1. Install floor sink at appropriate depth for top to be flush with flooring.
   2. Field cut grate top as required for drainage terminations.
   3. Provide with trap guard.

F. Water-Closet Installation:
   1. Provide toilet seat for each water closet.
   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.
   4. Floor mounted water closets shall be installed with a cast iron flange equivalent to Zurn CF2980. The flange shall be securely anchored to the floor. Provide wax ring for toilet installation.

G. Urinal Installation:
   1. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
   2. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
   3. Indicate on Drawings those urinals that are required to be accessible.
   4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC A117.1.
   5. Install trap-seal liquid in waterless urinals.

H. Lavatory Installation:
   1. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories.
   2. Anchor wall-mounted fixture to supports.
   3. Install countertop or undermount lavatories in countertop with appropriate support accessories.

I. Sink Installation:

1. Install countertop or undermount sinks in countertop with appropriate support accessories.
2. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks.

J. Drinking Fountain, Cuspidor and Electric Water Cooler Installation:
   1. Set freestanding, fixtures on floor.
   2. Anchor wall-mounted or recessed fixtures to supports.

K. 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 floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
   4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
   5. Use off-floor carriers with waste fitting and seal for back-outlet urinals or wall mounted drinking fountains, cuspidors and electric water coolers.
   6. Use carriers without waste fitting for urinals with tubular waste piping.
   7. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
   8. Install supports, affixed to building substrate, for wall-hung fixtures.
   9. Install mounting frames, affixed to building construction, and attach recessed fixtures to mounting frames.
   10.

L. Flushometer-Valve Installation:
   1. Install flushometer-valve, water-supply fitting on each supply to each water closet and urinal.
   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. Furnish transformer(s) as required for a group application of hard-wired water closets, urinals, and faucets.

M. Emergency Fixture Installation:
   1. Assemble emergency plumbing fixture piping, fittings, control valves, and other components
   2. Anchor or fasten fixtures to building substrate.
   3. Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
   4. Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
   5. Fill self-contained fixtures with flushing fluid.

N. 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.

O. Joint Sealing:
   1. Seal joints between fixtures and walls, counters, and floors using sanitary-type, one-part, mildew-resistant silicone sealant.

2. Match sealant color to fixture color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

P. Piping Connections: Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

Q. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.

## 3.3 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. Plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.4 ADJUSTING

A. Operate and adjust fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Install new batteries in battery-powered, electronic-sensor mechanisms.

C. Adjust fixture flow regulators for proper flow and stream height for all drinking fountains, cuspidors and electric water coolers.

D. Adjust electric water-cooler temperature settings.

E. Adjust water pressure at shower valves to produce proper flow.

## 3.5 CLEANING AND PROTECTION

A. Clean fixtures and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed fixtures and fittings.

C. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00

# SECTION 22 50 00 – PLUMBING EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Domestic water circulating pumps
   2. Electric domestic water heater
   3. Elevator sump pump

B. Related Requirements:
   1. Section 22 00 00 PLUMBING WORK

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

### 2.2 DOMESTIC WATER CIRCULATING PUMP

A. Domestic hot water circulating pump shall be lead free all bronze body with bronze impeller, line mounted, with capacities as scheduled. Refer to Division 23 21 40 for equivalent models to the scheduled pump.

## 2.3 ELECTRIC DOMESTIC WATER HEATER

A. Tank shall be steel, rated for 150 psi working pressure, all internal surfaces exposed to water shall be glass lined, insulated with foam insulation, exceeding ASHRAE 90.1., covered with a minimum 16 ga. outer jacket, and have baked enamel finish.

B. Heater shall have an ASME pressure/temperature relief valve, replaceable magnesium anode rods, non-metallic dip tube, and drain valve with hose end and cap.

C. Each heating element shall be controlled by an individually mounted thermostat and high temperature cut-off switch.

D. Heating tank shall have a three year warranty.

E. Water heater shall meet or exceed the capacity scheduled. Provide heater by A.O. Smith, or approved equivalent from Bock, Bradford White, Heat Transfer Products, Lochinvar, Ruud or State Industries.

## 2.4 ELEVATOR SUMP PUMP

A. Furnish and install where shown on the plans an elevator sump pump complete with pump, oil sensing pump control switch, high alarm float, and high water alarm panel.

B. Pump shall be non-clog centrifugal, submersible, vertical sump pump. Pump shall be high quality gray cast iron ASTM A-48, class 30 construction. Impeller shall be cast iron or bronze construction mounted to a type 303 stainless steel shaft with mechanical seals. Pump bodies shall have integral supporting feet. All pump trim shall be stainless steel for long service life.

C. Pump motors shall be either an oil filled or hermetically sealed air filled, class F insulation, 1750 RPM, with built-in auto reset thermal/overload protection. Oil filled motors shall have built-in probe to detect oil leaking through the pump seal(s). Pump electric cords shall be 600V UL approved for underwater operation with waterproof compression fitting at motor connection.

D. Pump shall have oil sensing pump control switch the sump pump will plug into. The switch shall start the pump upon sensing water and stop the pump upon sensing oil.

E. High alarm controller shall be in an NEMA 4 enclosure complete with alarm horn, alarm light and test buttons. The high alarm shall have one (1) dry contact to be monitored remotely.

F. Pumps shall be Liberty Pumps ELV Series, Goulds, Stancor, Weil, Zoeller, or approved equivalent.

# PART 3 - EXECUTION

## 3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete housekeeping pad, unless installation on stand, bracket, or suspended platform is indicated.

B. Maintain manufacturer's recommended clearances.

C. Arrange units so controls and devices that require servicing are accessible.

D. Arrange piping for easy removal of water heaters.

E. Anchor domestic-water heaters to substrate.

F. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
   1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
   2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
   3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.

G. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install commercial domestic-water heaters with seismic-restraint devices where scheduled.

## 3.2 DOMESTIC WATER INLINE CIRCULATOR INSTALLATION

A. Mount pumps in orientation complying with manufacturer's written instructions.

B. Install hanger rods, and vibration isolation were specified, near the pump of the size required to support pump weight.

C. Check piping connections for tightness.

D. Clean strainers on suction piping.

E. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

## 3.3 SUMP PUMP INSTALLATION

A. Pump Installation Standards: Comply with ANSI/HI 1.4 for installation of sump pumps.

## 3.4 FIELD QUALITY CONTROL

A. Complete installation and startup checks according to manufacturer's written instructions.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Testing:
   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, start units to confirm proper operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Domestic-water heaters, pumps, and associated controls, will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

## 3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heaters, circulators, pumps.

END OF SECTION 22 50 00

# SECTION 22 80 00 – PLUMBING SPECIALTIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Backflow preventer – reduced pressure
   2. Expansion tank
   3. Hose bibb – interior unfinished spaces
   4. Outlet drain box
   5. Pressure reducing valves
   6. Roof hydrant: exterior free standing roof mounted
   7. Solids interceptor
   8. Temperature relief valves
   9. Thermostatic mixing valves
   10. Thermostatic recirculation balancing valves
   11. Wall hydrant: exterior with box
   12. Wall hydrant: interior with box
   13. Water hammer arrestors
   14. Water meters

B. Related Requirements:
   1. Section 22 00 00 PLUMBING WORK

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

## 2.2 BACKFLOW PREVENTER - REDUCED PRESSURE

A. Furnish and install reduced pressure backflow preventer at water service entrance and at cross connection locations.

B. Assembly shall include shut off valves, strainer, test cocks, and pressure relief valve with ASME A112.1.2 air-gap fitting located between two positive seating check valves.
   1. Construction shall be all bronze with quarter-turn, full port, resilient seated ball valve shut offs for sizes 2” and smaller.
   2. 2-1/2” and larger shall be bronze, cast-iron, steel or stainless steel body and interior coating according to AWWA C550 or FDA approved epoxy coating with OS&Y resilient seated gate valve shut offs.

C. Discharge from air gap shall be piped to a floor drain.

D. Manufacturer:
   1. Watts model 994/957
   2. MIFAB/BEECO model FRP
   3. Conbraco Apollo RP4A
   4. Zurn Wilkins model 375/375AST (2-1/2” and larger)
   5. Zurn Wilkins model 975XL3 (2” and smaller).

## 2.3 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVES:

A. Combination Temperature-and-Pressure Relief Valves:
   1. ANSI Z21.22/CSA 4.4-M.
   2. 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.
   3. Select one relief valve with sensing element that extends into storage tank.
   4. Cash Acme, Kunkle, Spence, Watts, or approved equivalent.

## 2.4 EXPANSION TANK

A. Expansion tank shall be a steel hydro-pneumatic tank rated for a working pressure of 125 psig at 200°F.
   1. All internal wetted parts shall comply with FDA regulations and approvals.
   2. Capacity shall be as scheduled on the plans.

B. Installation:
1. Floor mounted tanks shall be installed on a 3-1/2" concrete housekeeping pad, refer to Section 20 00 00.
2. Support and anchoring of tanks is delegated design by the Contractor. Design operating weight shall be based on tank full of water.
3. Prior to opening the expansion tank to the system, the tanks shall be field charged by the Contractor and witnessed by the Engineer. Refer to expansion tank schedule and flow diagrams for charge pressure, if not indicated confirm with the Engineer.

C. Amtrol Therm-X-Trol or approved equal.

## 2.5 GAUGES

A. Provide 1/4" ball valves gauge cocks at all inlet and outlet of pumps and backflow preventers, at water service entrance, and where shown on piping isometrics, flow diagrams and details. Provide gauges where shown on piping isometrics, flow diagrams, and details.

B. Gauges shall be 4-1/2" diameter, flangeless aluminum/stainless steel safety case with removable ring, bottom connection, with a recalibrator, and have stainless steel tube and stainless steel movement calibrated to ½% accuracy, ANSI B40.1 Grade 2A with a pressure range appropriate for each system. Open water condenser systems shall have compound gauges. Gauges located at pumps shall be provided with a porous stone/metal type pressure snubber.

C. Gauges shall be Weiss Instruments UG2, Trerice 500XSS Series, Weksler AA44Y or equivalent by Marsh, or Marshalltown. Accessories from the same manufacturer shall be acceptable.

## 2.6 HOSE BIBB (HB-A): INTERIOR UN-FINISHED SPACES (COLD WATER ONLY)

A. 3/4" hose outlet x copper sweat inlet with integral vacuum breaker.

B. J.R. Smith 5673, MIFAB MHY-9200-NPB, Wade 8605, Woodford 26, or Zurn Z1341XL.

## 2.7 PRESSURE REDUCING VALVES

A. 3" and larger: automatic, pressure piloted, flanged cast iron body with interior coating according to AWWA C550, bronze or stainless steel trim, low flow bypass pressure control, pressure gauge connections, position indicator, and means for discharge pressure adjustment. Watts model LFF115-74, Zurn Wilkins model ZW209BP, Cla-Val model 90-48, or MIFAB ACV x.xx HF-PR.

B. 2-1/2" and smaller: automatic, internal diaphragm sensing, lead free bonze body, stainless steel seat, sealed spring cage, integral pressure by-pass, , cleanable stainless steel strainer. Watts model LFN223B/LFU5B-Z3, Cla-Val CRD-L or Zurn Wilkins model 500XL3/600XL.

## 2.8 ROOF HYDRANT: EXTERIOR FREE STANDING ROOF MOUNTED (RH-A)

A. Free standing roof hydrant with ¾" hose connection outlet with integral backflow preventer x 1"copper sweat inlet and 1/8" NPT drain hole. J.R. Smith 5906, MIFAB MHY-58, Watts HY-900, Woodford RHY2-MS or Zurn Z1388XL.

## 2.9 SOLIDS INTERCEPTOR:

A. Duco coated cast iron body and aluminum gasketed cover and removable stainless steel sediment bucket with fine mesh, stainless steel screen bucket liner and flow control fitting. Cover shall be chained to bucket. Installed on top of the floor, below the footprint of the sink.

B. J.R. Smith model 8710, or approved equal by Josam, MIFAB, Wade, Watts, or Zurn.

## 2.10 TEMPERATURE RELIEF VALVES:

A. Temperature relief valves on domestic hot water system shall be a self-contained, reverse acting, with adjustable setpoint.

B. Spence, ¾", 2020 TDGQF, or approved equivalent.

## 2.11 THERMOSTATIC MIXING VALVES

A. Furnish and install thermostatic tempering valves with integral check valves, removable cartridge strainers, stainless steel pistons, and thermal bellows – rough bronze finish. Valve shall be compliant with ASSE Standard 1017 and CSA B125. Thermostatic mixing valves in emergency fixture applications shall be compliant with ASSE 1071.

B. Leonard 210, Acorn MV-17, Armstrong RADA, Bradley S59, Lawler 310, Powers HydroGuard, Symmons TempControl, or approved equivalent.

## 2.12 THERMOSTATIC RECIRCULATION BALANCING VALVE

A. End of run domestic hot water lines shall be connected to the recirculation line with thermostatic recirculation valve. Valve shall be self-contained and fully automatic without additional piping or control mechanisms. Valve body and all internal components shall be constructed of stainless steel with major components constructed of type 303 stainless steel. Valve shall be NSF-61 certified with zero lead content for use in all domestic water systems. Temperature range shall be field adjustable. Valve shall incorporate a second element for 160°F high temperature bypass for thermal disinfection. Valve shall include inlet and outlet full port ball valves isolation valves to allow cartridge maintenance.

B. Sizes shall be indicated on the plans.

C. Factory set temperature to 115°F.

D. Operations
   1. Valve shall regulate the flow of recirculated domestic hot water based on water temperature entering valve regardless of system operating pressure.
   2. When fully closed valve shall bypass a minimum flow to maintain dynamic control of the recirculating loop and prevent pump deadheading.
   3. Valve shall be field adjustable from 105F to 140F as required by project conditions.
   4. At temperatures between 160-170°F second element will open for thermal disinfection.

5. Valve shall modulate between open and closed position within a 10F (5.5C) range.
6. Thermal actuator shall be spring operated and self cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits.

E. Caleffi ThermoSetter model 116-2X0A-001, Jomar TB-130G, Cimberio Valve model 778, or approved equivalent meeting the specifications.

2.13 WALL HYDRANT: EXTERIOR WITH BOX (WH-A)

A. 3/4” hose outlet x 3/4” (nominal) copper sweat straight inlet, non-freeze, anti-siphon wall hydrant with bronze casing, approved ASSE 1019 integral vacuum breaker and polished nickel bronze, stainless steel, or chrome-plated box.

B. Josam 71300, J.R. Smith 5519, MIFAB MHY-26, Wade W-8700, Watts HY-330, Woodford B65, or Zurn Z1300.

C. WALL HYDRANT: INTERIOR WITH BOX (WH-B)

D. 3/4” hose outlet x 3/4” (nominal) copper sweat straight inlet, anti-siphon wall hydrant with bronze casing, integral backflow preventer and polished nickel bronze or chrome plated box.

E. J.R. Smith 5509QT-SAP-NB, MIFAB MHY-35, Wade W-8708, Watts HY-330, Woodford B76, or Zurn Z1330-XL.

2.14 WATER HAMMER ARRESTOR

A. Furnish and install all stainless-steel shock absorbers at all solenoid, remote operated or quick closing valves such as restroom devices for each battery of fixtures. Install on both domestic hot and cold water branch lines in an upright position. Install where shown on the drawings and as required by code, provide access door when not accessible. Sized according to manufacturer’s recommended sizing.

B. Access door when not accessible shall be 8” x 8” square access covers with polished nickel bronze beveled edge frame with anchor lugs for over the wall installation, smooth stainless-steel cover, and vandal proof fasteners.

C. J.R. Smith Hydrotrol models 5005 to 5050, Josam 75000 series, MIFAB WHB, Precision Plumbing Products SBHA, or Zurn Z1700.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

A. Backflow Preventers: Install 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. Water Regulators: Install with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gauges on inlet and outlet.

C. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.

D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

E. Gauges
1. At pump locations utilizing factory taps in the casing or other locations where steel pipe is utilized, provide 1/4” brass screwed pipe and 1/4” 2-piece bronze threaded ball valve with lever handle for a gauge cock.
2. At locations where copper pipe is utilized, provide a ½” tee by line size connection in the piping and a ½” 2-piece bronze threaded ball valve, and 1/4” NPT bushing with lever handle for a gauge cock.
3. Gauges shall be installed as follows: 3” straight piping/nipple, service valve/gauge cock, tee with P/T plug in the run of the tee, and the gauge installed on the branch of the tee. There shall be no change in direction between the valve and the process pipe to allow cleaning an obstruction. The 3” is to create a dead leg to minimize sweating without insulating the valve.
4. All gauges shall be positioned where their view is unobstructed and can be easily read. If any gauge is unreadable, in the opinion of the Architect/Engineer, it shall be modified at the Contractor's expense.

F. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.

G. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow. Install in accordance with manufacturer’s instructions. Provide service valve on inlet to allow isolation for service, provide union to allow removal, provide 1/2“copper pipe or tubing from the primer unit to the floor drain or standpipe p-trap being primed.

H. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

## 3.2 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

D. Adjust each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly, and double-check, detector-assembly backflow preventer in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections**.**

B. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

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, start units to confirm unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

**END OF SECTION 22 80 00**

# TABLE OF CONTENTS

## DIVISION 23 – HVAC PIPING AND EQUIPMENT

## SECTION 23 00 00 – HVAC 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.

B. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 23 of these Specifications.
1. Section 23 10 00 – Flammable Gas and Liquids Piping and Equipment
2. Section 23 21 00 – Hydronic Piping and Equipment
3. Section 23 21 20 – Hydronic Pumps
4. Section 23 21 15 – Underground Hydronic Piping
5. Section 23 22 00 – Steam and Condensate Piping and Equipment
6. Section 23 25 00 – HVAC Water Treatment
7. Section 23 51 00 – Breechings, Chimneys, and Stacks
8. Section 23 57 00 – Heat Exchangers
9. Section 23 73 00 – Central Station Air Handling Units
10. Section 23 74 00 – Packaged HVAC Equipment
11. Section 23 81 00 – Unitary HVAC Equipment

C. Related Requirements:
1. Division 20 - Basic Mechanical, Plumbing, and Fire Protection
2. Division 25 - Temperature Control
3. Division 26 – Electrical

1.2 SUMMARY

A. Section Includes:
1. Cooling system including, but not limited to heat exchanger, piping, piping specialties, pumps, chemical water treatment system, chemical pot feeder, relief valves, air separator, and expansion tank.
2. Heating system including, but not limited to, exchanger(s), piping, chemical pot feeder, piping specialties, pumps, unit heaters, terminal heating coils, steam pressure reducing stations, relief valves, chemical pot feeder, air separator and expansion tank.
3. Air handling equipment including, but not limited to, central station air handling units, packaged rooftop air handling units, terminal units, relief fans, exhaust fans, and coils.
4. Make-up water connections including, but not limited to, piping, backflow preventers, pressure regulators, water meters, and electronic level sensors.
5. Chemical water treatment of chilled water, heating water, condenser water.
6. Draining, filling, and venting of all modified systems as required for the above work. This includes scheduling shutdowns with the Owner (Refer to Section 20 10 50).
7. All seismic restraints for the above work (Refer to Section 20 05 48).
8. Smoke stopping of all penetrations of pipes and ductwork, and firestopping of the same through fire rated partitions as shown on the Architectural drawings including, but not

limited to stairways, shafts, corridors, floors, roofs, and required exits (Refer to Section 20 10 40).

9. Cleaning and pressure testing equipment, piping, and accessories installed under this section of the specification. (Refer to Section 20 10 60).
10. Installing accessories specified under other sections of the specification referenced in Related Requirements, including but not limited to, flow meters, control valves, thermowells, and taps for pressure sensors.

## 1.3 QUALITY ASSURANCE

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20.

B. Specific requirements for materials shall be as listed in Division 20 Basic Materials and Methods.

C. Manufacturer's mill reports and applicable documents to certify the validity of the procured piping materials shall be on file at the Contractor's office.

D. Install all piping with pitch to vent or drain. Provide drain valves at low points and air vents at high points. Drain valves and air vents shall be ¾' bronze 2 piece body ball valves with ¾" hose end adapter, cap and chain. In ½" through 2" pipe, contractor may use Webstone model T-drain. Use eccentric reducing fittings (installed top level) as required to avoid air pockets.

E. Gaskets and packings containing asbestos are not acceptable.

F. Where pipe and accessories installed under this section of the specification tie-in to existing systems, Contractor shall verify existing for: sizes, direction of flow (via pressure or physical tracing of piping, not labels), materials, and elevations before installing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

G. Prior to excavation, best efforts shall be made to locate existing lines with cameras, locating sondes, ground penetrating radar, etc.

## 1.4 ACTION SUBMITTALS

A. Contractor shall submit coordination drawings to the Engineer for review prior to any fabrication or installation. (Refer to Section 20 10 50).

B. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

C. Refer to Division 1, Division 20, and each section of Division 23.

D. At the point where the mechanical system has been installed and checked by the Contractor and the systems are ready for testing and adjusting, submit a letter to the Architect/Engineer stating such. Refer to Section 20 10 85.

## 1.5 INFORMATIONAL SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 23

## 1.6 CLOSEOUT SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 23.

B. As-built drawings of underground piping or equipment shall include dimensions from building walls/columns and elevations.

C. At the completion of the project, submit a letter stating all materials are asbestos free, and meet the specified ASTM E-84 flame/smoke rating of 25/50, and that all piping and duct penetrations are smoke or fire stopped as required by the Code.

# PART 2 - PRODUCTS (Not Applicable)

# PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 00 00

## SECTION 23 08 00: COMMISSIONING OF HVAC SYSTEMS

## PART 1 GENERAL

### 1.1 SUMMARY

A. The work under this Section is subject to requirements of the Contract Documents including the Owner's General Conditions and articles of the Construction Manager's General Conditions.

B. General commissioning requirements are detailed in Division 01.

C. The commissioning process does not reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product in accordance with the Contract Documents.

D. This section shall in no way diminish the responsibility of the Division 23 Contractors, Subs and Suppliers in performing all aspects of work and testing as outlined in the contract documents. Any requirements outlined in this section are in addition to requirements outlined in Division 01 and 23 Specifications.

### 1.2 RELATED DOCUMENTS

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

B. The requirements in this section are in addition to those specifically outlined in:

1. Section 01 91 13 – General Commissioning Requirements

### 1.3 HVAC EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. The following equipment and systems shall be commissioned as part of this project. All general references to equipment and systems within this document refer only to those identified below:

1. AHUs
2. Chilled Water System
3. Heating Hot Water System
4. Terminal Units
5. Fans
6. Unit Heaters
7. Building Automation and Control Systems

### 1.4 REFERENCES

A. Refer to Section 01 91 13 for applicable references for work associated with this section.

### 1.5 DEFINITIONS & ABBREVIATIONS

A. Refer to Section 01 91 13 for definitions and abbreviations for terms in this section.

## 1.6 COMMISSIONING TEAM

A. Refer to Section 01 91 13 for commissioning team members.

## 1.7 COMMISSIONING SUBMITTALS

A. Refer to Section 01 91 13 for additional required commissioning submittals.

B. TAB Plan:

1. The GC/CM, with assistance from the TABC, shall develop a TAB Plan and execute TAB utilizing the following procedure.

2. Compile detailed TAB forms according to the TABC's certifying agency standard. TAB documentation shall include specific boxes or lines for recording and documenting data of each piece of equipment.

3. Submit the TAB Plan to the CxA for review and include the following at a minimum:

    a. Table of Contents.

    b. Detailed description of how TAB will be completed. Specifically, the TAB Plan shall identify any diversity in system designs and how the TAB process will account for this.

    c. Schedule of TAB activities by equipment (initial TAB Plan submittal schedule shall be tentative; TAB schedule shall be updated as construction proceeds and forwarded to CxA).

    d. Separate tagged divider by system and equipment with TAB forms and documentation.

4. The CxA, A/E and OR reviews the TAB Plan for content and format. The CxA shall return the TAB Plan with comments to GC/CM and the GC/CM shall revise the TAB Plan based on CxA comments.

5. The GC/CM shall forward copies of the completed TAB Plan to CxA, A/E and OR for review. Any comments that require re-TAB are the responsibility of the GC/CM until results are acceptable.

6. After the completed TAB Plan is approved, the CxA will execute on-site verification of selected readings reported in the TAB Plan. The TABC must supply the technician who performed the measurements and the equipment used for verification.

7. Once all TAB activities are complete, the GC/CM shall submit a complete, compiled TAB Plan for review documentation. Any comments made by the CxA shall be incorporated.

# PART 2 PRODUCTS

## 2.1 TEST EQUIPMENT

A. Refer to Section 01 91 13 for additional test equipment requirements.

B. If not otherwise specified, the following minimum requirements apply.

1. Temperature sensors and digital thermometers shall have a certified accuracy of 0.5°F and a resolution of ±0.1°F.

2. Pressure sensors shall have an accuracy of ±2.0% of the value range being measured (not full range of meter).

## PART 3 EXECUTION

### 3.1 COMMISSIONING PROCESS OVERVIEW

A. Refer to Section 01 91 13 for an overview of the commissioning process.

### 3.2 ROLES AND RESPONSIBILITIES

A. Refer to Section 01 91 13 for roles and responsibilities of additional team members.

B. Controls Contractor Responsibilities

1. Include costs for all commissioning requirements in contract price.

2. Review and provide feedback on the FPT test procedures developed by the CxA.

   a. Ensure all test procedures are executable with the control system as programmed. This includes overriding all points as indicated.

   b. Verify all graphics, trend logs and alarms are programed and active as indicated in the contract documents and FPT test procedures.

3. Any tasks indicated within the FPT scripts do not override any other start-up and checkout tasks identified in Division 23. It is the CC responsibility to ensure the system is fully operational and operating in automatic mode prior to execution of FPTs.

4. Provide trained and certified technician familiar with the project programming to execute the FPT test procedures at the direction of the CxA.

C. TAB Contractor Responsibilities

1. Include costs for all commissioning requirements in contract price.

2. Develop the TAB Plan in coordination with the GC/CM.

3. Make revisions to TAB work as identified by the CxA, A/E and/or OR for conformance with the contract documents.

4. Make the certified technicians and equipment used in creating the completed TAB Plan available to the CxA for TAB Verification activities.

### 3.3 SCHEDULING AND COORDINATION

A. Refer to Section 01 91 13 for scheduling and coordination requirements.

### 3.4 PRE-FUNCTIONAL CHECKLISTS

A. Refer to Section 01 91 13 for PFC requirements.

### 3.5 START-UP AND INITIAL CHECKOUT

A. Refer to Section 01 91 13 for Start-Up and Checkout requirements.

### 3.6 TESTING, ADJUSTING AND BALANCING

A. The GC/CM shall develop the TAB Plan and submit to the CxA, A/E, and OR for approval a minimum of thirty (30) days prior to the anticipated start of TAB activities.

B. After receiving approval of the TAB Plan, the GC/CM shall organize and lead a TAB Coordination Meeting. All CT members shall attend and provide feedback on TAB activities.

C. The TABC shall execute TAB activities per the TAB Plan.

D. Once the completed TAB Plan has been reviewed, the CxA will conduct on-site TAB verification.

1. TABC shall supply the technician(s) who took the original readings and the equipment used as reported in the completed TAB Plan.

2. The CxA will identify a sample of readings that the TABC shall reproduce. The CxA shall confirm that the equipment and techniques used to gather the measurements are correct and the readings are accurate.

3. Any discrepancies identified will be identified as Cx Issues and tracked on the Cx Issues Log.

a. If issues are limited or minor in nature, the CxA will recommend only the identified issues be remedied.

b. If issues are numerous or the CxA that identified issues are systemic, the CxA will reject the completed TAB Plan and require the process to be repeated.

E. The GC/CM shall notify the CxA of any changes to the TAB schedules that will affect commissioning activities. The CxA will work with the GC/CM and TABC to schedule new dates as necessary. The GC/CM shall notify the CxA a minimum of five (5) days in advance of scheduled commissioning visits if re-scheduling is required.

1. Any time for the CxA to visit the site to execute commissioning tasks on equipment or systems that were identified as being ready by the GC/CM but found to not be will be back charged to the GC/CM at a cost of $2,500 plus expenses per man-day.

F. The GC/CM shall provide the CxA with signed and dated copy of completed TAB Plan documents prior to scheduling of FPTs. Only individuals having direct knowledge that a line item task was actually performed shall complete the documentation.

G. The TABC shall clearly list outstanding items or initial TAB tasks that are not completed successfully. Completed forms documenting any outstanding deficiencies shall be provided to CxA within two (2) working days of completion.

### 3.7 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 13 for FPT requirements.

## 3.8 NON-CONFORMANCE AND COMMISSIONING ISSUES

A. Refer to Section 01 91 13 for information regarding Non-Conformance and Cx Issues.

## 3.9 OWNER TRAINING

A. The GC/CM is responsible for execution of Owner Training as outlined in section 01 79 00.

**END OF SECTION 23 08 00**

# SECTION 23 21 00 – HYDRONIC PIPING AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Heating system including, but not limited to, heat exchanger(s), piping, chemical pot feeder, piping specialties, pumps, unit heaters, terminal heating coils, steam pressure reducing stations, relief valves, chemical pot feeder, air separator and expansion tank.
2. Air handling equipment including, but not limited to, central station air handling units, packaged rooftop air handling units, terminal units, relief fans, exhaust fans, and coils.
3. Make-up water connections including, but not limited to, piping, backflow preventers, pressure regulators, water meters, and electronic level sensors.
4. Chemical water treatment of heating water.
5. Draining, filling, and venting of all modified systems as required for the above work. This includes scheduling shutdowns with the Owner (Refer to Section 20 10 70).
6. All seismic restraints for the above work (Refer to Section 20 10 40).
7. Smoke stopping of all penetrations of pipes and ductwork, and firestopping of the same through fire rated partitions as shown on the Architectural drawings including, but not limited to stairways, shafts, corridors, floors, roofs, and required exits (Refer to Section 20 10 20).
8. Cleaning and pressure testing equipment, piping, and accessories installed under this section of the specification. (Refer to Section 20 10 50).
9. Provide sufficient labor and resources required for the testing and balancing (Refer to Section 20 10 80) and for the commissioning process (Refer to Section 152300).
10. Installing accessories specified under other sections of the specification referenced in Sub-section 23 00 05, including but not limited to, flow meters, control valves, thermowells, and taps for pressure sensors.

B. Related Requirements:
1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: The Contractor shall submit the following for approval.
1. Piping materials, valves, and accessories as specified in Piping Materials Schedule(s) in this section of the specification.
2. All specialties including, but not limited to, thermometers, gauges, relief valves, pressure regulators, backflow preventers, flow switches, and vacuum breakers.
3. All general items specified under Division 20 utilized in the installation of work required by this section of the specification.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MISCELLANEOUS PIPING REQUIREMENTS

A. Itemization of the piping materials for specific system application are enumerated in the following sub-sections for the respective PIPING MATERIAL SCHEDULE. Specific requirements for materials shall be as listed in Division 20 “Basic Mechanical Conditions”.

B. Manufacturer's mill reports and applicable documents to certify the validity of the procured piping materials shall be on file at the Contractor's office.

C. Install all piping with pitch to vent or drain. Provide drain valves at low points and air vents at high points. Drain valves and air vents shall be ¾’ bronze 2 piece body ball valves with ¾” hose end adapter, cap and chain. In ½” through 2” pipe, contractor may use Webstone model T-drain. Use eccentric reducing fittings (installed top level) as required to avoid air pockets.

D. Gaskets and packings containing asbestos are not acceptable.

E. Where Pipe and accessories installed under this section of the specification tie-in to existing systems, Contractor shall verify existing for: sizes, direction of flow (via pressure or physical tracing of piping, not labels), materials, and elevations before installing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

## 2.3 HYDRONIC SPECIALTIES

A. AIR SEPARATOR
   1. Air separators shall be designed, constructed, and stamped for 125 psig at 350°F in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code. Centrifugal type air separator shall have tangential or bottom outlet, tangential inlet, stainless steel collector tube without strainer. Coalescing type air separate shall have internal copper coalescing medium. Air separator shall have flanged inlet and outlet with a threaded drain connection.
   2. Air separator shall be Spirovent model HV or equivalent.

B. AUTOMATIC AIR VENT

1. Automatic air vents shall be high capacity, float actuated, cast iron or cast brass body, stainless steel/brass trim and rated for 150 psi at 250°F.
2. Automatic air vents shall have their discharges piped to a drain.
3. Automatic air vents shall be Spirotherm model Spirotop or equivalent.

C. SAFETY VALVES, RELIEF VALVES, SAFETY RELIEF VALVES
1. Valves shall be factory set and field verified for 125 psi, bronze body, stainless steel trim and test/lift lever. Pressure relief valves shall be a minimum of ¾" Bell and Gossett Model 790, Watts 174A, Kunkle or equivalent.
2. Valves shall be ASME Code Section VIII rated, bronze body and brass trim. Safety relief valves shall be Kunkle, Bell and Gossett, Watts or equivalent.

D. MAKE-UP WATER CONNECTION
1. Backflow preventer shall be of reduced pressure type. Assembly shall include shut off valves, strainer and air gap connection. Backflow preventer shall be Watts Series 909 or equivalent.
2. Pressure reducing valves shall be Watts U5, Bell and Gossett #7, Taco 335, Armstrong HRD70 or equivalent.
3. Meters shall be Neptune T-10, Kent C-700, or Hersey MTX 123, or equivalent.
4. Meters shall be in-line horizontal-axis type per AWWA Class II, flanged cast bronze body, permanently roll-sealed register, turbine measuring chamber, stainless steel spindle, and graphite bearings. Meters shall be furnished with pulse transmitters for remote monitoring. Meters shall be Neptune HP Turbine, Kent T-3000, Hersey MTX/WTX, or equivalent.

E. THERMOMETERS
1. Thermometers shall be organic spirit filled in a 9" polyester or aluminum case, magnified lens, glass or acrylic front, black divisions and numbers. Accuracy shall be ± one scale division. Stem shall be tapered aluminum installed in a brass thermowell.
2. The submittal data shall clearly identify the range and the service the thermometers are used for.
3. Thermometers shall be Weksler AS5, Trerice model Adjustable Angle, Weiss Vari-angle, MILJOCO 935, or equivalent.

F. TEST PORTS
1. Test ports shall be pressure and temperature test plugs. Plugs shall be self-sealing plugs. EPDM/Nordel seals rated for the temperature, pressure and fluid associated with the application and shall be capable of accepting a needle type temperature or pressure probe and reclosing when the probe is removed. Acceptable manufacturers and models are as follows:

| Manufacturer | Model |
|---|---|
| Peterson Engineering | Pete's Plug |
| Trerice | Pressure / Temperature Test Plug |
| Sisco | P/T Plugs |
| Bell and Gossett | Read-Out Valve RV-125A |

2. Alternatively, access fittings may be provided in place of the Pete's Plugs. In this case, the fittings shall be provided with a retained cap and shall be Mueller Brass A-17130 or equivalent.

G. GAUGES

1. Gauges shall be 4-1/2” diameter, flangeless aluminum/stainless steel safety case with removable ring, bottom connection, with a recalibrator, and have stainless steel tube and stainless steel movement calibrated to ½% accuracy, ANSI B40.1 Grade 2A with a pressure range appropriate for each system.
2. Gauges shall be Weiss Instruments UG2, Trerice 500XSS Series, Weksler AA44Y or equivalent by Marsh, or Marshalltown. Accessories from the same manufacturer shall be acceptable.

## 2.4 EXPANSION TANKS

A. Furnish, install, and charge expansion tanks as indicated on the plans, flow diagrams, and schedules. The tanks shall be field charged by the Contractor to provide 10 psig at the high point of the system with all pumps not operating for positive venting.

B. Expansion tanks shall be constructed in accordance with Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code and stamped for a minimum working pressure of 150 psi 200°F. The tanks shall have a standard schrader charging valve (.302” – 32) connection for on-site adjustment of the system pressure. The tanks shall be provided with mounting hardware for either vertical base mount or saddles for horizontal mounting in the configuration shown or scheduled on the drawings.

C. Diaphragm type tanks shall have a non-replaceable heavy duty butyl rubber diaphragm to separate the air charge and the system water. The minimum system connection size shall be ½” NPT.

D. Diaphragm type expansion tanks shall be Amtrol AX Series, Bell and Gossett Series D, Taco CAX series, Thrush AX series or approved equivalent.

E. Bladder type tanks shall have replaceable bladder constructed of heavy duty butyl rubber. The water shall be in bladder, and the air shall be in the tank. The minimum system connection size shall be 1” NPT. The tank shall have a ¾” NPT drain to allow draining water from the tank in the event of a bladder failure. The tank shall have both vertical and horizontal lifting rings.

F. Bladder type expansion tanks shall be Amtrol L series, Bell and Gossett Series B, Taco CA series, Thrush L series or approved equivalent.

# PART 3 - EXECUTION

## 3.1 PIPING APPLICATIONS

A. PIPING MATERIAL SCHEDULE M-1
1. Service
    a. Chilled water supply and return for HVAC. (Unless specified otherwise)
    b. Hot water (heating) supply and return for HVAC.

2. Design Rating:
    a. 125 PSIG at 350°F
    b. 175 PSIG at 150°F

3. Pipe (Refer to Section 20 10 10):

| SIZE | MATERIAL | THICKNESS |
|---|---|---|
| 3” and Smaller | Copper | Type L |
| 2½ ” and Smaller (Contractor Option) | Black Carbon Steel ASTM-A53, ERW | Schedule 40 |
| 3” to 10” | Black Carbon Steel ASTM-A53, ERW | Schedule 40 |

a. Contractor may use either copper or black carbon steel for piping 3” and smaller. Fittings shall be as noted herein.

4. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | Joining Method |
|---|---|---|
| 3” and Smaller | Wrought Copper | Solder Ends |
| 2½ ” and Smaller (Contractor Option) | Cast Iron | Screwed |
| 3” to 10” | Black Carbon Steel | Buttwelded |

a. Copper piping notes:
   1) All solder connections shall use 95/5 solder.
b. Carbon steel notes:
   1) Elbows shall be long radius.
   2) See Division 20 for acceptable branch arrangement in lieu of tee fitting.
   3) Wall thickness of the fittings shall be consistent with the connecting piping.
c. Grooved connections may be used at vertical branch drops to equipment located within mechanical rooms. Grooved fittings shall be painted ductile iron, smooth (segmented or welded fittings are not acceptable), and with grooved ends. Wall thickness consistent with connecting pipe. To be used in conjunction with compatible rigid mechanical couplings designed specifically for this application.
d. All piping concealed in chases or walls or above inaccessible ceilings shall be welded.

5. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | Joining Method |
|---|---|---|
| 3” and Smaller | Wrought Copper | Solder Ends |
| 2½ ” and Smaller (Contractor Option) | Cast Iron | Screwed |
| 3” to 10” | Black Carbon Steel | Buttwelded |

a. Copper piping notes:
   1) All solder connections shall use 95/5 solder.
b. Carbon steel notes:
   1) Elbows shall be long radius.
   2) See Division 20 for acceptable branch arrangement in lieu of tee fitting.
   3) Wall thickness of the fittings shall be consistent with the connecting piping.
c. All fittings must be soldered or welded. Mechanical joining methods are not allowed except as otherwise noted.

6. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | Joining Method |
|---|---|---|
| 3” and Smaller | Wrought Copper | Solder Ends |
| 2½ ” and Smaller (Contractor Option) | Cast Iron | Screwed |
| 3” to 10” | Black Carbon Steel | Grooved |

a. Copper piping notes:
   1) All solder connections shall use 95/5 solder.
b. Carbon steel notes:
   1) Elbows shall be long radius.
   2) See Division 20 for acceptable branch arrangement in lieu of tee fitting.
   3) Wall thickness of the fittings shall be consistent with the connecting piping.
c. Grooved Fittings: Painted ductile iron, smooth (segmented or welded fittings are not acceptable), grooved ends. Wall thickness consistent with connecting pipe. To be used in conjunction with compatible rigid mechanical couplings designed specifically for this application.
d. All piping concealed in chases or walls or above inaccessible ceilings shall be welded.

7. Valves (Refer to Section 20 10 20):

| SERVICE | SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|---|
| Shut-off | 3” and Smaller | Two Piece, Full Port<br>Bronze Body<br>Stainless steel ball and trim | Ball |
| Shut-off | 2½” and Larger | Cast iron body | Butterfly |
| Balancing / Throttling | 12” and Smaller | | Multi-Turn Calibrated Balance Valve. |
| Check Valve (General Duty) | All | Class125 | Swing Check |
| Check Valve (Pump Discharge) | 2½” and Smaller | Class 125 | Swing Check |
| Check Valve (Pump Discharge) | 3” and Larger | Class 125<br>Cast iron body | Silent check |
| | | | |

8. Straineres (Refer to Section 20 10 20)

| SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|
| 4” and Smaller | Class 125, Cast Iron | Y-Pattern |
| 5” and Larger | Class 125, Cast Iron | Basket Type |

9. Flanges:

| SIZE | MATERIAL/CONSTRUCTION | PIPING / FITTING TYPE |
|---|---|---|
| 4” and Smaller | Class 125 ASME standard or Class 150, Cast Copper companion type, soldered end | Copper / Soldered |
| 2½” and Larger | Class 150, Black forged carbon steel, weld neck pattern | Black Carbon Steel / Welded |
| 2½” and Larger | ANSI Class 150, Victaulic 45 | Black Carbon Steel / Grooved |

10. Unions
    a. 3” and smaller Wrought copper, solder ends
11. Vibration Isolation at Pumps Without Inertia Bases:
    a. Provide and install two (2) Victaulic style 177 couplings (or approved equal) at each pump inlet and outlet connection.

12. Vibration Isolation:
    a. Refer to individual equipment sections for required vibration isolation accessories.
13. Pressure Test (Refer to Section 20 10 xx):
    a. Hydrostatic test at 200 PSIG for two (2) hours minimum

B. PIPING MATERIAL SCHEDULE M-2
1. Service: Non-Potable Make-up water for hydronic systems
2. Design Rating: 175 PSIG at 150°F

3. Material Specifications (Refer to Section 20 10 10):

| COMPONENT | MATERIAL |
|---|---|
| Pipe | Copper |
| Pipe Wall Thickness | Type L |
| Fittings | Wrought Copper |
| Joining Method | Solder Ends |
| Service Valves | Two piece Ball Valve, Bronze Body, Stainless steel ball and trim |

4. Pressure Test (Refer to Section 20 10 xx):
    a. Hydrostatic test at 200 PSIG for two (2) hours minimum

C. PIPING MATERIAL SCHEDULE M-3
1. Service: Condensate Drain Piping
2. Design Rating: Atmospheric
3. Material Specifications (Refer to Section 20 10 10):

| COMPONENT | MATERIAL |
|---|---|
| Pipe | Copper |
| Pipe Wall Thickness | Type L |
| Fittings | Wrought Copper |
| Joining Method | Solder Ends |
| Service Valves | Two piece Ball Valve, Bronze Body, Stainless steel ball and trim |

    a. 90° elbows are not permitted, use (2) 45° elbows or 'Y' provided with cap in unconnected straight run.
    b. Extend piping from all cooling coil drain pans to the location of discharging indirectly to the building drain system. Pipe size shall be unit connection size unless indicated larger on the plans.
    c. Connections to the drain pans shall be made through a water seal trap with the downstream side vented to atmosphere.

4. Pressure Test:
    a. Pressure test at not less than 15 feet static head of water for two (2) hours minimum.

## 3.2 INSTALLATION

A. Install all piping with pitch to vent or drain. Provide drain valves at low points and air vents at high points. Drain valves and air vents shall be ¾' bronze 2 piece body ball valves with ¾" hose end adapter, cap and chain. In ½" through 2" pipe, contractor may use Webstone model T-drain. Use eccentric reducing fittings (installed top level) as required to avoid air pockets.

B. Gaskets and packings containing asbestos are not acceptable.

C. Where Pipe and accessories installed under this section of the specification tie-in to existing systems, Contractor shall verify existing for: sizes, direction of flow (via pressure or physical tracing of piping, not labels), materials, and elevations before installing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

D. Hydronic Specialties
1. Air Separators
a. Furnish and install centrifugal type or coalescing type air separator where shown on the plans or flow diagrams.
2. Automatic Air Vent
a. Automatic air vents shall be furnished and installed for all centrifugal air separators.
3. Safety Valves, Relief Valves, Safety Relief Valves
a. Hydronic systems containing heat exchangers or other unfired heating vessels shall have safety relief valves sized for the rated output of each device at the pressure rating of the lowest pressure device.
b. Discharges from valves shall be piped to floor drains for water valves and to the outdoors for steam valves.
4. Pump Flowline Fitting (Suction Diffuser)
a. Furnish and install a pump flowline fitting with strainer at all inlets to base mounted pumps. Fitting shall be coordinated with pump inlet size and system piping, where largest system size available is smaller than the system piping, provide piping reducer at inlet of flowline fitting.
5. Make-up Water Connection
a. At all make-up water locations to hydronic systems provide a line size reduced pressure backflow preventer, pressure reducing valve, water meter, and a pressure relief valve. In closed system the pressure reducing valve and water meter shall be ¾". In open systems the pressure reducing valve and water meter shall be line size.
b. Pressure reducing valves shall be furnished and installed for each system and field adjusted for each system to provide 10 psi at the highest point in the system with all pumps off for positive venting.
c. Water meter 1" and smaller shall be a totalizing positive displacement meter indicating in U.S. Gallons meeting AWWA Standard C-700 latest edition.
d. Water meter 1 ¼" and larger shall be a totalizing magnetic turbine meter indicating in U.S. Gallons meeting AWWA Standard C-701 latest edition
6. Thermometers
a. Thermometer wells and thermometers shall be provided at the inlet and outlet of all air handling unit coils and where shown on the plans, piping isometrics, flow diagrams and details.
b. Stem length and lagging length shall be coordinated with the piping and the insulation. A minimum 2" insertion length shall be in the moving fluid.
c. Thermometers for use in chilled water having 1°F increments are preferred with a minimum range of 30°F - 100°F, in no case shall the range be greater than 0°F - 160°F having 2°F increments.
d. Thermometers for use in heating water systems shall have 2°F increments with a range of 30-240°F.
e. Where thermometer wells are installed below 5 feet they shall be installed on the side of vertical piping or on the top of horizontal piping so that they can be angled back beyond vertical to allow easy reading. Where thermometer wells are installed

above 6 feet they can be installed on the face or the side of vertical piping and for horizontal piping it should be installed between 9 and 12 o'clock to allow the thermometers to be angled less than vertical without the pipe blocking the view of the thermometer.

f. Prior to installing the thermometer wells, the contractor shall have the thermometers at the jobsite and shall demonstrate to the Architect/Engineer where they intends to install them where they will be easy to read. If the Contractor fails to perform the above, any thermometers which are unreadable, in the opinion of the Architect/Engineer, it shall be modified at the Contractor's expense.

7. Test Ports
   a. Provide pressure and temperature test plugs at locations shown on the plans, flow diagrams and details.
   b. Furnish extensions for test ports installed in insulated piping. Plugs shall be provided with threaded protective caps. One temperature and pressure test kit suitable for the plugs used on the job shall be provided to the Owner on all installations where the plugs are used.
8. Gauges
   a. Provide 1/4” ball valves gauge cocks at all inlet and outlet of air handling units and across control valves of air handling units and at the inlet and outlets of heat exchangers, pumps, etc. and where shown on piping isometrics, flow diagrams and details. Provide gauges where shown on piping isometrics, flow diagrams, and details.
   b. Open water condenser systems shall have compound gauges.
   c. Gauges located at pumps shall be provided with a porous stone/metal type pressure snubber.
      1) Utilizing factory taps in the casing or other locations where steel pipe is utilized, provide 1/4” brass screwed pipe and 1/4” 2-piece bronze threaded ball valve with lever handle for a gauge cock.
   d. At locations where copper pipe is utilized, provide a ½” tee by line size connection in the piping and a ½” 2-piece bronze threaded ball valve, and 1/4” NPT bushing with lever handle for a gauge cock.
   e. Gauges shall be installed as follows: 3” straight piping/nipple, service valve/gauge cock, tee with P/T plug in the run of the tee, and the gauge installed on the branch of the tee. There shall be no change in direction between the valve and the process pipe to allow cleaning an obstruction. The 3” is to create a dead leg to minimize sweating without insulating the valve.
   f. All gauges shall be positioned where their view is unobstructed and can be easily read. If any gauge is unreadable, in the opinion of the Architect/Engineer, it shall be modified at the Contractor's expense.

E. Expansion Tanks
1. Furnish, install, and charge expansion tanks as indicated on the plans, flow diagrams, and schedules. The tanks shall be field charged by the Contractor to provide 10 psig at the high point of the system with all pumps not operating for positive venting.
2. Diaphragm tanks shall meet or exceed both the minimum acceptance volume and total volume as scheduled. Diaphragm type tanks shall only be used when scheduled as such, otherwise expansion tanks shall be bladder type tanks.
3. Bladder tanks shall meet or exceed the total volume as scheduled.

END OF SECTION 23 21 00

# SECTION 23 21 15 – UNDERGROUND HYDRONIC PIPING

## PART 1 – GENERAL

### 1.1 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for chilled-water piping installed underground.

B. This Section does not include chilled water piping installed inside buildings or utility tunnels.

C. Drawings and general provisions of Contract, including General Conditions, apply to the work of this Section. Section 23 0100 "Basic Mechanical Requirements" and Section 23 0500 "Basic Mechanical Materials and Methods" apply to the work of this Section.

D. Related Sections include the following:
  1. Division 23 Section "Hydronic Piping" for chilled water piping installed inside buildings or utility tunnels.
  2. Division 23 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements, and for labeling and identifying hydronic piping.
  3. Division 23 Section "Valves" for general-duty ball and butterfly valves.

E. The following two types of piping systems and methods are included in this Section:
  1. Traditional open-trench method.
  2. Directional boring method.

### 1.2 DEFINIINTIONS

A. DI: Ductile iron.

B. PVC: Polyvinyl chloride plastic.

### 1.3 REFERENCED STANDARDS

A. ASTM D1784: Standard for Rigid PVC Compounds and Chlorinated PVC Compounds.

B. ASTM D2837: Standard Test Method for Obtaining Hydrostatic Design Basis for Thermo- plastic Pipe Materials.

C. ASTM D3139: Standard Specification for Joints for Plastic Pipes Using Flexible Elastomeric Seals.

D. ASTM F477: Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

E. AWWA C900: Standard for PVC Pressure Pipe Fabricated Fittings, 4-inch through 12-inch, for Water Distribution.

## 1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with a minimum working-pressure rating of 150 psig.

## 1.5 SUBMITTALS

A. Submit product data for the following:
   1. Pipe, valves and fittings.
   2. Restraining devices.
   3. Valve boxes and vent boxes.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For valves and specialties to include in emergency, operation, and maintenance manuals.

## 1.6 QUALITY ASSURANCE

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

B. Comply with ASTM F645 for selection, design, and installation of thermoplastic water piping.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves according to the following:
   1. Ensure that valves are dry and internally protected against rust and corrosion.
   2. Protect valves against damage to threaded ends and flange faces.
   3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves according to the following:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. 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.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Stacking of the pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. Where necessary due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

G. Protect flanges, fittings, and specialties from moisture and dirt.

H. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

## 1.8 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 Owner's Representative no fewer than seven days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's Representative written permission.

# PART 2 – PRODUCTS

## 2.1 MANUFACTURERS

A. Ball Valves: Subject to compliance with requirements, provide ball valves by thefollowing:
1. Conbraco Industries, Inc.; Apollo Div.; Model 77-100.

B. Butterfly Valves: Subject to compliance with requirements, provide buried butterfly valves by one of the following:
1. General Signal; DeZurik Unit.
2. Mueller Co.; Water Products Div.
3. Henry Pratt Company.
4. Val-Matic Valve & Manufacturing Corp.

C. Relief Valves: Subject to compliance with requirements, provide air/vacuum relief valves by one of the following:
1. Crispin-Multiplex Manufacturing Co.
2. GA Industries, Inc.
3. Val-Matic Valve & Manufacturing Corp.

D. PVC Pipe Joint Restraints: Subject to compliance with requirements, provide PVC pipe joint restraint by one of the following:
1. Traditional open-trench method: Use EBAA Megalug 2000 PV retainers, and/or Certainteed Certa-Lok C900/RJ couplings, or approved equal.
2. Directional boring method: Use Certainteed Certa-Lok C900/RJ couplings.

## 2.2 BURIED PIPING (PVC)

A. PVC Pipe: AWWA C900, Pressure Class 150, dimension ratio DR 18; equivalent outside diameter to ductile iron pipe, with precision-machined grooves for use with pipe manufacturer's proprietary coupling system, Certa-Lok C900/RJ restrained joint PVC pipe.

B. Pipe and couplings shall be made from unplasticized PVC compounds having a minimum cell classification of 12454, as defined in ASTM D1784. The compound shall qualify for a Hydrostatic

Design Basis (HDB) of 4000 psi for water at 73.4F, in accordance with the requirements of ASTM D2837. As defined in AWWA C900, pipe and couplings shall be homogeneous throughout and free from voids, cracks, inclusions, and other defects, and shall be as uniform as commercially practicable in color, density, and other physical characteristics.

C. Pipe shall be furnished in standard lengths of 20 feet.

D. Pipe shall be legibly and permanently marked in ink with the following information.
  1. Manufacturer and Trade Name
  2. Nominal Size & DR Rating/Pressure Class
  3. Manufacturing Date Code

E. Restrained Mechanical-Joint, Ductile-Iron Pipe: AWWA C151 mechanical joint pipe; 150 psi working pressure; minimum thickness Class 52; with integrally cast bell, gland, and rubber gasket.

F. Restrained Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and stainless-steel bolts.
  2. Lining: Standard cement lining with asphalt coating.
  3. Encasement: AWWA C105, high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

2.3 BURIED PIPING (PRE-INSULATED COPPER PIPING)

A. Carrier pipe shall be Type K Copper tube, conforming to ASTM B-88. (At the Engineer's option, Type L or Type M is acceptable.) Cleaned and Capped Type K, and ACR Type L copper tube may be used for cryogenic and refrigeration applications. All copper piping shall have ends cut square for socket brazing. Straight sections of factory insulated pipe shall be 20-foot in length and shall have 6" of exposed pipe at each end for field joint fabrication. Field joining of piping shall utilize approved methods of brazing with alloys melting at or above 1100°F; 50-50 tin-lead solder is not acceptable.

B. Insulation shall be polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket with a minimum thickness of one inch. Insulation shall be rigid, 90% minimum closed cell polyurethane with a minimum 2.0 lbs. per cubic foot density, compressive strength of 30 psi @ 75°F, and coefficient of thermal conductivity (K-Factor) of not higher than 0.16 @ 75°F per ASTM C-518. Maximum operating temperature shall not exceed 250°F. Insulation thickness shall be specified by calling out appropriate carrier pipe and jacket size combinations as listed on drawing CUSG 6.103 or 6.104.

C. Jacketing material shall be either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). PVC jacket shall have a wall thickness in mils equal to ten times the nominal jacket diameter and shall not be less than 60 mils. HDPE shall have a minimum wall of 100 mils for jacket sizes less than or equal to 12", 125 mils for jacket sizes greater than 12" to 24" and 150 mils for all jacketing larger than 24". No FRP, HDUP, or tape jacket allowed.

D. Straight run joints are insulated using urethane foam to the thickness specified, jacketed with either an HDPE or PVC sleeve and sealed with pressure sensitive, polyethylene backed, rubberized bitumen adhesive tape, 30 mils thick, or a heat shrink sleeve or tape. Above ground installations shall use white, pressure sensitive PVC tape.

E. Fittings are Thermacor SC (standard components) factory pre-fabricated and pre-insulated with urethane to the thickness specified, jacketed with a molded fitting cover or a PVC fitting cover wrapped with polyethylene backed, pressure sensitive rubberized bitumen adhesive tape, 30 mils thick. Carrier pipe fittings shall be brazed with alloys melting at or above 1100°F; 50-50 tin-lead solder is not acceptable. Fittings include expansion loops, elbows, tees, reducers, and anchors. (At the Engineer's option, system may be pre-engineered.)

F. Expansion/contraction compensation will be accomplished utilizing factory pre-fabricated and pre-insulated expansion elbows, Z-bends, expansion loops, and anchors specifically designed for the intended application. External expansion compensation utilizing flexible expansion pads minimum one inch thick extending on either side, both inside and outside the radius of the fittings, is used with all fittings having expansion in excess of 1/2".

## 2.4 JOINING MATERIALS

A. Fitting Restraints for PVC Pipe to DI Fitting Connection: AWWA C111 mechanical joint. Provide retainer type packing glands with rubber gasket, for use with PVC pipe and conforming to Uni-B-13-92 and FM approved. EBAA Megalug 2000 PV or approved equal.
   1. Rods, Nuts and Washers: ¾" SS304 all thread rods, nuts and washers, or EBAA Mega Bond Coating System.

B. Fitting Restraint for PVC Pipe to DI Fitting Connection: AWWA C110 mechanical joint. Provide retainer type packing glands, for use on all classes of ductile iron pipe and UL listed and FM Approved EBAA Megalug 1100 or approved equal.
   1. Rods, Nuts and Washers: ¾" SS304 all thread rods, nuts and washers, or EBAA Mega Bond Coating System.

C. Fitting Restraints for Pipe Couplings: Use Certainteed Certa-Lok C900/RJ proprietary couplings system. Substitute couplings systems must be submitted and approved prior to bid and shall have been tested and approved by an independent third-party laboratory for continuous use at rated pressure. Copies of Agency approval reports or product listing shall be provided to the Engineer.
   1. The pipe shall be joined using a separate PVC coupling with beveled edges, built-in sealing gaskets and restraining grooves. The restraining splines shall be square or rectangular, and made from Nylon 101.
   2. The pipe shall be joined using non-metallic couplings which, together, have been designed as an integral system for maximum reliability and interchangeability. High- strength flexible thermoplastic splines shall be inserted into matting precision-machined groves in the pipe and coupling to provide full 360 degree restraint with evenly distributed loading.
   3. Couplings shall be designed for use at the rated pressure of the pipe with which they are utilized, and shall incorporate twin elastomeric sealing gaskets meeting the requirements of ASTM F477. Joints shall be designed to meet the leakage test requirements of ASTM D3139.

## 2.5 BURIED COMPONENTS

A. Valve Sizes: Same as upstream pipe size, unless otherwise indicated.

B. Valve Flanges: ASME B16.1 for cast-iron valves and ASME B16.24 for bronze valves.

C. Valve Threaded Ends: With threads according to ASME B1.20.1.

D. Material Substitution: Ductile iron is acceptable anywhere cast iron is specified.

E. Class Substitution: If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

F. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering “CHILLED WATER” and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter. A precast concrete valve box with a manhole cast in the top would be an acceptable substitution.
   1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

G. Relief Vents:
   1. Vents are to be installed at high points of the system.
   2. Service Saddle
      a. Services saddles for pipes 2-inches thru 24 inches diameter shall be Mueller DR2S Series Ductile Iron with stainless steel single strap.
   3. Air/Vacuum Relief Valves: Spirotop Automatic Air Vent
      a. Standard: AWWA C512
      b. Pressure Rating: 300 psig.
      c. Body Material: Solid brass
      d. Nominal Size: 1-inch NPS.
   4. Vent Boxes:
      a. Roadway, parking lots and service drives: Heavy duty, street rated cast iron with hot dip galvanized finish. Removable cover shall be checkered steel with stainless steel cover screws shall be marked “CHILLED WATER.” Junction box shall have an H-20 load rating and be suitable for installation in roadway. Minimum dimensions shall be 12” x 12” x24” (L x W x D).
      b. Grass and sidewalks: Vent box shall be 18” PVC pipe, ASTM F679, SDR 35, with cast iron water well cover. Lid shall be marked “CHILLED WATER.”

H. Ball Valves: Provide Series 77-140-series “Apollo” ball valves by Conbraco Industries, Inc.; or Watts B6080-SS. Products of manufacturers other than these are considered Substitutions and are not permitted, except as provided under the General Conditions and Division 01 Specifications. The Owner has no obligation to accept any substitution.
   1. Minimum SWP rating: 150-psig.
   2. Minimum CWP rating: 600-psig.
   3. Body: ASTM B584 bronze, two-piece construction.
   4. Ball: Type 316 stainless steel, full port.
   5. Stem: Blowout-proof Type 316 stainless steel; extended-length stem to accommodate insulation.
   6. Packing: PTFE or TFE.
   7. Ends: Threaded. Sweat end connections will be rejected.
   8. Handle: Vinyl-covered steel lever with memory stop; and zinc-plated steel nut.

I. Butterfly Valves: Valve shall conform to AWWA C504; sizes NPS 3 and larger.

1. Type: Rubber seated.
2. Minimum CWP rating: 150-psig.
3. Body and bonnet: ASTM A536 ductile-iron, extended neck.
4. Packing: Field-replaceable EPDM or BUNA-N sleeve and stem seals.
5. Stem and Stem Hardware: Type 316 stainless steel.
6. Disc: Aluminum bronze.
7. End Connections: Flanged (in vaults); or Mechanical Joint compatible with AWWA C111 fittings.
8. Operator: Gear drive with fully-greased packed actuator with stops in the open and closed position.

## PART 3 – EXECUTION

### 3.1 EARTHWORK

A. Refer to Division 23 Section “Utility Excavation and Backfill” for excavating, trenching, and backfilling.

B. Refer to Division 23 Section “Directional Boring” for trenchless installation requirements.

### 3.2 BURIED PIPING APPLICATION

A. Except where otherwise noted, the Contractor may choose among the following two types of piping systems and methods:
1. Traditional open-trench method: Direct-bury, including but not limited to excavation of pipe trench, bedding, backfill, and site restoration; using PVC pipe with Certainteed Certa-Lok C900/RJ proprietary couplings and restrained joint, ductile iron fittings and concrete thrust blocking at changes of direction.
2. Directional boring method: Use PVC pipe, Certainteed Certa-Lok C900/RJ proprietary couplings system and restrained joint, ductile iron fittings and concrete thrust blocking at changes of direction.

### 3.3 BURIED PIPING INSTALLATION

A. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. 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. Clean pipe of debris prior to installation.

B. Open Trench Method:
1. Remove any standing water in the bottom of trench.
2. Bed the pipe on a layer of granular fill material with clearance between the pipes as detailed on the Drawings.
3. Do not backfill piping trench until field quality-control testing has been completed and results approved.

4. Bury piping with depth of cover over top at least 30 inches and as detailed on the Drawings if applicable.
5. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.
6. Install piping free of sags and bends.

C. Directional Boring Method: Refer to Division 23 Section “Directional Boring.”

D. Install components with pressure rating equal to or greater than system operating pressure.

E. Install fittings for changes in direction and branch connections. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, anchors, tie-rods and clamps, and other supports, install per manufacturer's recommendations.

F. Refer to Division 23 Section “Basic Mechanical Materials and Methods” for sleeves and mechanical sleeve seals through tunnel and exterior building walls.
   1. Connect to hydronic piping where it passes through the tunnel and exterior building walls. Hydronic piping inside the tunnel and building walls is specified in Division 23 Section “Hydronic Piping.” Extend new hydronic service piping and connect to existing hydronic piping systems in locations and pipe sizes indicated.

G. Protect open ends of pipe at the end of each workday, with a temporary hard cap or inflatable plug.

H. All ferrous components, including but not limited to cast or ductile iron pipe, fittings, valves, and specials, shall be externally wrapped with AWWA C105, high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.

## 3.4 JOINT CONSTRUCTION

A. Make pipe joints according to the following:
   1. Ductile-Iron Piping, Gasketed Joints Piping: AWWA C600 and AWWA M41.
   2. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.

B. Make pipe joints for EBAA Megalug and/or Certainteed Certa-Lok C900/RJ proprietary couplings systems in strict accordance with the respective manufacturer’s written instructions.

## 3.5 ANCHORAGE INSTALLATION

A. Anchorage, General: Install hydronic distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
   1. Concrete thrust blocks. Concrete is specified in Division 03 “Cast-in-Place Concrete.”
   2. Locking mechanical joints.
   3. Set-screw mechanical retainer glands.
   4. Proprietary couplings systems as specified in Part 2 of this Section.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and branches. Include anchorages for gasketed-joint PVC piping according to AWWA M23.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

## 3.6 BURIED VALVE INSTALLATION

A. Buried Valve Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Drawings indicate valve types to be used.

B. AWWA Butterfly Valves: Comply with AWWA C600 and AWWA M44.

C. MSS Valves: Install as component of connected piping system.

D. Relief Valves: Comply with AWWA C512. Install in vault with shutoff valve on inlet.

## 3.7 IDENTIFICATION

A. Open-trench method: Install continuous underground detectable warning tapes during back filling of trenches for underground hydronic distribution piping. Locate 12 inches below finished grade, directly over piping. Refer to Division 23 Section “Utility Excavation and Backfill” for warning-tape materials and devices and their installation. Also, install custom- color #12 AWG THWN electrical tracer wire during the pipe installation for underground hydronic distribution piping. Locate directly on piping and adhere with tape or bands. Terminate tracer wire within building or utility tunnel with a minimum 24-inch length neatly coiled and clipped to the wall.

B. Directional boring method: Install custom-color #12 AWG THWN electrical tracer wire during bored pipe installation for underground hydronic distribution piping. Locate directly on piping and adhere with tape or bands. Terminate tracer wire within building or utility tunnel with a minimum 24-inch length neatly coiled and clipped to the wall.

C. Tracer wire described above shall be furnished and installed in custom insulation colors matching Missouri State University standard.
1. Purple with white stripe shall be used for chilled water supply.
2. Pink with white stripe shall be used for chilled water return.

## 3.8 FIELD QUALITY CONTROL

A. Prior to testing, a safety/testing procedure meeting will be held.

B. Prepare hydronic piping for Hydrostatic testing according to ASME B31.9 and Missouri State University standard testing procedure as follows:
1. Air tests are not allowed under any circumstances.
2. Leave joints, including welds, uninsulated and exposed for examination during test.
3. Isolate equipment. Do not subject equipment to test pressure.
4. Install relief valve set at pressure no more than one-third higher than test pressure.
5. Fill system with water.
6. Use vents installed at high points to release trapped air while filling system, see drawings.

7. Pressure gauges shall be stainless steel Bourdan tube, liquid filled, mechanical with 0 psi to 200 psi range (effective pressure range 50 psi to 175 psi).

C. Test hydronic piping as follows:
1. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
2. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
3. Hydrostatic pressure should be held for 2 hours.
4. Prepare a written report of testing and submit to Owner's Representative.

3.9 CLEANING

A. Clean and flush hydronic distribution piping, following procedures described in AWWA C651. The system does not require disinfection. Clean and flush piping until no visible solids are present in samples as determined by Owner's Representative.

B. Flush water supply is to be from a fire hydrant and 2-inch hose. Drain through 2-inch hose to storm sewer.

C. Care shall be taken to prevent dirt and debris from entering piping system when removing test connections and making final tie-ins.

D. Submit reports for all purging activities to Owner's Representative.

END OF SECTION 23 21 15

# SECTION 23 21 20 – HYDRONIC PUMPS AND ACCESSORIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Close-coupled, in-line centrifugal pumps.
   2. Automatic condensate pump units.

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Pumps described herein and indicated on the drawings are based on the manufacture and model number listed under each sub-section. Where pumps are from manufacturers not scheduled the following criteria shall apply: Pumps shall be picked at scheduled flow and head with working fluid of the system which the pump is in, pump impeller shall not be within ½” of the smallest or largest size for the pump body, pump efficiency shall not more than 5% less efficient than scheduled pump, operation point shall not exceed nameplate horsepower, pump motor size shall not be larger than scheduled motor. Pumps which are used in parallel installations shall be sized such that the brake horsepower does not exceed the motor horsepower when only one pump is running. This operating point shall not be off the manufacturer’s published pump curve.

## 2.2 GENERAL

A. Furnish and install circulating pumps for water service of the base mounted or in-line configuration as scheduled on the drawings. Pumps shall be factory tested, aligned, painted, and shipped complete for installation. Electrical characteristics shall be as scheduled on the plans.

## 2.3 IN-LINE PUMPS

A. General: In-line pumps and circulators shall be suitable for mounting in either vertical or horizontal piping with the motor mounted as specified below. Pumps shall be flanged and provided with a companion flange having NPT tappings or shall be ANSI Standard B16.1 flanges. Pumps shall have factory taps, shipped with plugs installed, for measuring suction and discharge pressure, and at the low point in the volute to allow draining.

B. Cartridge type circulators shall be bronze or iron construction as scheduled. Pumps shall be maintenance free, horizontal (motor and shaft installed position) in-line, single stage, wet rotor type with the motor mounted directly to the pump volute rated for 125 psi, 230°F operation. The integral motor shall be cooled and lubricated by the pump fluid. The motor stator shall be isolated from the circulated fluid through use of a stainless steel rotor can. The pump shaft shall be ceramic supported by ceramic/carbon bearings. Circulators shall be Bell and Gossett Fox series, Armstrong Astro series, Grundfos series UP, Taco “00” series, or approved equivalent.

C. Circulators shall be bronze or iron construction as scheduled. Pumps shall be horizontal (motor and shaft installed position) in-line, oil lubricated, one-piece dynamically balanced impeller, and flexible coupling. Pumps shall be rated for 125 psi at 225°F. Mechanical seals shall be two piece with a carbon seal face and ceramic seat rated for continuous operation at 225°F. Motors shall be open drip-proof type with sleeve bearings, quite operating, rubber mounted, with built-in thermal overloads. Circulators shall be Bell and Gossett Booster pump, Armstrong series S & H, Taco Red Baron Circulator , or approved equivalent.

D. Horizontal in-line pumps shall be bronze or iron construction as scheduled. Pumps shall be horizontal (motor and shaft installed position) in-line type, oil lubricated, one-piece cast bronze impeller dynamically balanced, and flexible coupled. Pumps shall be rated for a maximum working pressure of 175 psi at 150°F and 150 psi at 250°F. Mechanical seals shall be two piece design with a carbon seal face and ceramic seat rated for continuous operation at 225°F. Pump shall be of a three-piece design consisting of: the volute, bearing module, and the motor; with each section bolted to the next. The bearing module shall have oil lubricated bronze journal and thrust bearings. The motor shall be joined to the pump shaft through a flexible coupling. Motors shall be NEMA B letter design with a 1.15 service factory, open drip-proof, premium efficiency. Pumps shall be Bell and Gossett series 60, Armstrong series 1060, Taco 1600 series, or approved equivalent.

E. In-line pumps shall be bronze fitted Class 30 cast iron body designed for either horizontal or vertical (motor and shaft installed position) in-line mounting, oil lubricated, one piece cast bronze dynamically balanced impeller, replaceable bronze wear rings, steel pump shaft with replaceable bronze shaft sleeve, close/split coupled. Pumps shall be rated for a maximum working pressure of 175 psi at 150°F and 150 psi at 250°F (125# ANSI flange). Mechanical seals shall be flushed two piece design with a carbon seal face and ceramic seat rated for continuous operation at 225°F. Motors shall be NEMA JM, with a 1.15 service factor regreaseable ball bearings, vertical shaft, drip-proof enclosure, premium efficiency. Pumps shall be Bell and Gossett series 80, Armstrong 4380/4300 series, Taco KS model, or approved equivalent.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations for suitable conditions where pumps will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

A. Piping at pumps shall be arranged to facilitate pump maintenance. Piping shall be arranged so that the service valves can be closed and the piping and specialties between the service valves and pump removed for servicing and to allow clear access to the pump for removal as required. Where pump connection sizes are smaller than the line sizes associated with the suction and discharge piping, concentric reducers or increasers shall be installed immediately at the pump flanges to adapt to the indicated line size. All specialties and service valves associated with the pump such as strainers, check valves, etc., shall be line size, and not pump connection size.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

D. Inline Pumps
   1. General: Where in-line pumps are installed in horizontal or vertical piping, the pump shall be rigidly mounted to the piping with pipe hangers on each side of pump, but the motor shall not be supported. Where in-line pumps are supported from the floor using a pipe stand/column then two flexible mechanical couplings shall be used on each side of the pump for vibration isolation.

E. Equipment Mounting:
   1. Unit shall be installed on 3-1/2” concrete pad. Refer to Section 20 00 00 BASIC MECHANICAL CONDITIONS.
   2. After installation of the base mounted pumps and anchoring the base in place, the Contractor shall follow manufacturer’s instructions for filling the steel bases with grouting cement. Pump bases which are to be grouted shall be grouted prior to the final alignment.
   3. Refer to flow diagram and details for piping specialties for the pumps.

4. Following the completion of all piping connections, pump couplings and drives shall be systematically aligned using approved methods and instruments. Before putting the pumps into service, the alignment shall be approved by the Architect/Engineer.
5. Comply with requirements for vibration isolation and seismic-control devices specified in Section 200548 "Vibration and Seismic Controls for HVAC."
6. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
   a. Comply with requirements for hangers and supports specified in Section 20 10 30 "Hangers. Shields, Supports, and Anchors."

3.3 CLEANING AND PROTECTION

A. Clean

3.4 STARTUP

A. Where existing systems are modified, provide start-up strainers at all existing pumps. Strainers shall be removed after 72 hours of operation.

END OF SECTION 23 21 20

# SECTION 23 22 00 – STEAM AND CONDENSATE PIPING AND EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Steam specialties
   2. Steam piping

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Itemization of the piping materials for specific system application are enumerated in the following sub-sections for the respective PIPING MATERIAL SCHEDULE. Specific requirements for materials shall be as listed in Division 20 Basic Mechanical Materials.

C. Manufacturer's mill reports and applicable documents to certify the validity of the procured piping materials shall be on file at the Contractor's office.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 MISCELLANEOUS PIPING REQUIREMENTS

A. Gaskets and packings containing asbestos are not acceptable.

## 2.2 STEAM SPECIALTIES

A. Vacuum Breaker (Steam Heat Exchangers and Steam Coils):
1. Furnish and install at all heat exchangers and entering side of steam coils a vacuum breaker rated for a maximum working pressure of 150 psig and 366°F operating temperature.
2. Vacuum breakers shall be Bell and Gossett No. 26, or approved equal.

B. Pressure Regulators:
1. Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff. Valves shall have cast-iron body, hardened stainless-steel trim, replaceable head and seat, main head stem guide fitted with flushing and pressure-arresting device, cover over pilot diaphragm, and non-asbestos gaskets.
2. Main valve – Spence E, cast iron body, 2-1/2” and larger 125 lb. flanges, 2” and smaller 250 lb. threaded.
3. Pressure regulator - Spence D5, 5-25 psig range.
4. See schedule for sizes, capacities, and operating pressures.

C. Temperature Regulators:
1. Pilot-actuated, diaphragm type, with adjustable temperature range and positive shutoff. Valves shall have cast-iron body, hardened stainless-steel trim, replaceable head and seat, main head stem guide fitted with flushing and pressure-arresting device, cover over pilot diaphragm, and non-asbestos gaskets.
2. Main valve – Spence E2, cast iron body, 2-1/2” and larger 125 lb. flanges, 2” and smaller 250 lb. threaded.
3. Temperature regulator – Spence T134, style 704 bronze temperature bulb and temperature well, 70°F – 170°F range, 10 ft. brass flexible tubing.
4. See schedule for sizes, capacities, and operating pressures.

D. Float and Thermostatic Traps:
1. Float and Thermostatic Traps: ASTM A126, cast-iron body and bolted cap; renewable, stainless steel float mechanism with renewable, hardened stainless-steel head and seat; maximum allowable pressure of 125 psig; balanced-pressure, stainless-steel or monel thermostatic bellow element. Thermostatic air vent capable of withstanding 45°F of superheat and resisting water hammer without sustaining damage.
2. Steam traps shall be Armstrong, Hoffman, Spirax Sarco, or Watson McDaniel.
3. See schedule for sizes, capacities, and operating pressures.

E. Inverted Bucket Traps:
1. Inverted Bucket Traps: ASTM A126, cast iron body and bolted cap; renewable, stainless steel float mechanism with renewable hardened chrome steel valve and seat; maximum allowable pressure of 250 psig.
2. Steam traps shall be Armstrong, Hoffman, Spirax Sarco, or Watson McDaniel.
3. See schedule for sizes, capacities, and operating pressures.

F. Flash Tanks:
1. Shop or factory fabricated of welded steel according to the ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPA) rating; and bearing ASME label. Fabricate with tappings for vents, low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.
2. Flash Tank shall be a horizontal style tank, similar to the Armstrong HAFT, or approved equivalent.

3. Provide flash tank with removable insulation cover.
4. Provide flash tank with gauge glass.

G. Blowdown Separator
1. Furnish and install a blowdown separator as shown on the plans. The separator shall be manufactured in accordance with ASME Code for a minimum of 150 psig. The separator shall have internal baffling/ strike plates, 150# ANSI flanged connections, automatic drain aftercooler, remote bulb temperature regulator valve, bi-metal thermometer, and floor stand.

H. Pressure Driven Steam Trap and Pump Combination
1. Acceptable Manufacturers
   a. Armstrong Intl, Inc. Model DD-6
2. Body shall be an ASME code stamped carbon steel vessel rated to 200 psig @ 400°F with all stainless steel internals. The pump mechanism shall incorporate Inconel X-750 springs for superior service life. Springs made of materials other than Inconel X-750 shall not be accepted. Single compression springs shall not be accepted. Motive and vent connections shall have externally replaceable seats for viewing and inspecting the internal valves.
3. Internal pump and steam trap mechanisms shall not be integrally linked components for ease of maintenance and repair.
4. Motive Force. The Pump Trap shall utilize steam to remove condensate from the receiving vessel.
5. Trap/Pump shall require no electricity for operation.
6. The DD-6 shall include a bronze water level gauge with shut off valves.
7. Overall height of the trap/pump shall not exceed 16.7”.
8. The pump shall have 150# RF flanges for condensate inlet and outlet.
9. Check valves shall be WLC wafer style constructed of carbon steel with stainless steel trim.
10. Provide Trap/Pump with pressure gauge assembly.

## 2.3 EXAMINATION

A. Examine existing conditions.

## 2.4 INSTALLATION

A. Install all piping with pitch to vent or drain. Provide 150 pound ball valves with hose end adapter at all low points and manual key operated air vents at all high points. Use eccentric reducing fittings (installed bottom level) as required to avoid air pockets.

B. Steam systems shall be defined as: low pressure when operating between 0-15 psig, medium pressure when operating between 16-50 psig, high pressure when operating above 51 psig.

C. In steam systems service valves and strainers shall be installed with the stem/basket in the horizontal position so that condensate flow is not impeded.

D. Install pigtail siphon at all pressure gauge and pressure transmitter locations. Refer to Section 23 10 09 for gauge specifications.

## 2.5 PIPING APPLICATIONS

A. STEAM PIPING MATERIAL SCHEDULE M-1

1. Service
   a. Steam supply: Low pressure, medium pressure, steam vents, steam relief boiler feed, boiler blowdown, boiler overflow.

2. Design Rating:
   a. 125 PSIG at 350°F

3. Pipe (Refer to Section 20 10 10):

| SIZE | MATERIAL | WALLTHICKNESS |
|---|---|---|
| 10” and Smaller | Black Carbon Steel ASTM-A53, ERW | Schedule 40 |

4. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | JOINING METHOD |
|---|---|---|
| 2” and Smaller | Cast Iron, 125# | Screwed |
| 2½” to Larger | Black Carbon Steel, standard schedule | Buttwelded |

   a. All piping concealed in chases or walls or above inaccessible ceilings shall be welded.

5. Valves (Refer to Section 20 10 20):

| SERVICE | SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|---|
| Shut-off | 2” and Smaller | Class 125, bronze body | Gate Valve |
| Shut-off | 2½” thru 12” | Class 125, iron body | Gate Valve |
| Balancing / Throttling | 2” and Smaller | Class 125, bonze body | Globe Valve |
| Balancing / Throttling | 2½” thru 12” | Class 125, iron body | Globe Valve |

6. Strainers (Refer to Section 20 10 20)

| SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|
| All | Class 125, Cast Iron | Y-Pattern |

7. Flanges:

| SIZE | MATERIAL/CONSTRUCTION | PIPING / FITTING TYPE |
|---|---|---|
| All Sizes | Class 150, Black forged carbon steel, weld neck pattern | Welded |

8. Pressure Test (Refer to Section 20 10 00):
   a. Hydrostatic test at 200 PSIG for two (2) hours minimum

B. STEAM PIPING MATERIAL SCHEDULE M-2

1. Service
   a. Steam supply: High pressure

2. Design Rating:
   a. 150 PSIG at 400°F

3. Pipe (Refer to Section 20 10 10):

| SIZE | MATERIAL | WALL THICKNESS |
|---|---|---|
| 10” and Smaller | Black Carbon Steel ASTM-A106, Seamless | Schedule 40 |

4. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | WALL THICKNESS |
|---|---|---|
| 2” and Smaller | Cast Iron, 250# | Screwed <Rated to 250 psig at 400°F> |
| 2½” to Larger | Black Carbon Steel, standard schedule | Buttwelded |

a. All piping concealed in chases or walls or above inaccessible ceilings shall be welded.

5. Valves (Refer to Section 20 10 20):

| SERVICE | SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|---|
| Shut-off | 2” and Smaller | Class 300, bronze body <Rated to 300 psig at 550°F> | Gate Valve |
| Shut-off | 2½” and Larger | Class 150, steel body <Rated to 150 psig at 550°F> | Gate Valve |

6. Strainers (Refer to Section 20 10 20)

| SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|
| All | Class 250, Cast Iron | Y-Pattern |
| | | |

7. Flanges:

| SIZE | MATERIAL/CONSTRUCTION | PIPING / FITTING TYPE |
|---|---|---|
| All Sizes | Class 150, Black forged carbon steel, weld neck pattern <Rated to 150 psig at 500°F> | Welded |

8. Pressure Test (Refer to Section 20 10 00):
   a. Hydrostatic test at 200 PSIG for two (2) hours minimum

C. CONDENSATE RETURN PIPING MATERIAL SCHEDULE
1. Service
   a. Condensate return (all types)

2. Design Rating:
   a. 125 PSIG at 220°F

3. Pipe (Refer to Section 20 10 10):

| SIZE | MATERIAL | WALL THICKNESS |
|---|---|---|
| 5” and Smaller (Contractors Option) | Copper | Type L |
| 5” and Smaller | Black Carbon Steel ASTM-A53, ERW | Schedule 80 |

4. Fittings (Refer to Section 20 10 10):

| SIZE | MATERIAL | Joining Method |
|---|---|---|
| 2½” and Smaller | Extra Heavy Cast Iron, 250# | 250# Screwed |
| 3” thru 5” | Black Carbon Steel, Schedule 80 | Buttwelded |

a. All piping concealed in chases or walls or above inaccessible ceilings shall be welded.

5. Valves (Refer to Section 20 10 20):

| SERVICE | SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|---|
| Shut-off | 2” and Smaller | Class 125, bronze body | Gate Valve |
| Shut-off | 2½” and Larger | Class 125, iron body | Gate Valve |
| Check Valve | 2” and Smaller | Class 125, bonze body | Sing Check |

6. Strainers (Refer to Section 20 10 20)

| SIZE | MATERIAL/CONSTRUCTION | TYPE |
|---|---|---|
| 4” and Smaller | Class 125, Cast Iron | Y-Pattern |
| 5” and Larger | Class 125, Cast Iron | Basket Type |

7. Flanges:

| SIZE | MATERIAL/CONSTRUCTION | PIPING / FITTING TYPE |
|---|---|---|
| All Sizes | Class 150, Black forged carbon steel, weld neck pattern | Welded |

8. Pressure Test (Refer to Section 20 10 00):
    a. Hydrostatic test at 150 PSIG for two (2) hours minimum

## 2.6 INSTALLATION

A. Steam Condensate Pump
1. Unit shall be installed on 3-1/2” concrete pad. Refer to Section 20 00 00 BASIC MECHANICAL CONDITIONS.
2. Route full size unit drain line to floor drain/sink. Provide with service valve on the unit drain line. Route full size overflow line with 12” trap (overflow loop) to spill over floor drain/sink. Route ½” drain line with service valve from condensate main to unit drain line.
3. Route full size unit vent to discharge to outside the building at a safe location per code.
4. Pipe connections to unit shall not be interfere with unit control panel. Contractor to review the manufacturer manual for the exact locations.
5. Refer to flow diagram and details for piping specialties on the discharge of the pumps.
6. Install in accordance with manufacturer’s instructions and as shown on the drawing.
7. Insulation. Install the removable insulation cover in accordance with manufacturer’s instructions.

## 2.7 CLEANING AND PROTECTION

A. Clean

END OF SECTION 23 22 00

# SECTION 23 25 00 – HVAC WATER TREATMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: HVAC water treatment.
   1. Manual chemical-feed equipment.
   2. Automatic chemical-feed equipment
   3. Chemicals.
   4. Inhibited ethylene glycol and propylene glycol.
   5. Filtration equipment.

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. PPM: Parts per million.

C. RO: Reverse osmosis.

D. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

E. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

F. LSI: Langelier’s Stability Index predicts the tendencies of water

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.4 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## 1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

# PART 2 - PRODUCTS

## 2.1 SERVICE PROVIDERS

A. The following companies
   1. Chemtron RiverBend

## 2.2 PERFORMANCE REQUIREMENTS, GENERAL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

C. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

## 2.3 PERFORMANCE REQUIREMENTS FOR CLOSED-LOOP HYDRONIC SYSTEMS

A. Closed hydronic systems, shall maintain the following water qualities:
   1. pH: Maintain a value between 9.0 to 11.0.
   2. Conductivity: less than 4000 µmhos
   3. Nitrate: 300-600 ppm in Chilled water, 500-1000 in heating water
   4. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion to less than 0.1 mils per year.
   5. Stainless Steel Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to less than 0.1 mils per year.
   6. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to less than 0.1 mils per year.
   7. Scale Control: Provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
   8. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
   9. Microbiological Limits:
      a. Total Aerobic Plate Count: Maintain a maximum value of 1,000 organisms/mL.
      b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.

## 2.4 MANUAL CHEMICAL-FEED EQUIPMENT WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

A. Bypass Feeders: Feeders shall be cast iron bulk type feeders complete with connections for water in, treated water outlet, drain, isolation and drain valves, and removable covers. Feeders shall be Ball feeder type, rated for continuous operation at 200 psi and 250°F, Dearborn Type AV, J.L. Wingert Co., Neptune VTF or equivalent.

1. Heating Water: 5-gallon feeder

# PART 3 - EXECUTION

## 3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

## 3.2 INSTALLATION

A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.

B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install interconnecting control wiring for chemical-treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

## 3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in "General-Duty Valves for HVAC Piping."

E. See "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

## 3.4 ELECTRICAL CONNECTIONS

A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

B. Ground equipment in accordance with "Grounding and Bonding for Electrical Systems."

C. Connect wiring in accordance with "Low-Voltage Electrical Power Conductors and Cables."

## 3.5 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Engage a qualified testing agency to perform tests and inspections.

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

C. Tests and Inspections:

   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC system's startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
   8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

D. Prepare test and inspection reports.

E. Comply with ASTM D3370 and with the following standards:

   1. Silica: ASTM D859.
   2. Steam System: ASTM D1066.
   3. Acidity and Alkalinity: ASTM D1067.
   4. Iron: ASTM D1068.
   5. Water Hardness: ASTM D1126.

## 3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for heating, steam and condensate piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

## 3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 23 25 00

# SECTION 23 57 00 – HEAT EXCHANGERS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Shell and U-tube Heat Exchangers.

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 SHELL and U-TUBE - Building Heating Water

A. Steam to water heat exchanger shall be constructed according to ASME Section VIII, Division 1.

B. Materials:
   1. Shell: Steel
   2. Head: Cast iron. Flanged and bolted to shell.
   3. Tube: Cupronickel tubes.
      a. Tube diameter is determined by manufacturer based on service.
   4. Tubesheet Materials: Brass.

5. Baffles: Brass.

C. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
   1. NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.
   2. NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

D. Support Saddles:
   1. Fabricated of material similar to shell.
   2. Fabricate foot mount with provision for anchoring to support.

E. Manufacturers: Bell and Gossett Type WU, Armstrong Type W, Taco GL, or approved equivalent.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine existing conditions.

### 3.2 INSTALLATION

A. Furnish and install heat exchangers as scheduled and shown on drawings.

B. SHELL-AND-TUBE HEAT EXCHANGER
   1. Install heat exchangers on saddle supports.
   2. Heat-Exchanger Supports: Mount heat exchanger on steel saddles and supports specifically designed for each heat exchanger.
   3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

C. PIPNG CONNECTIONS
   1. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.
   3. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.
   4. Install shutoff valves at heat-exchanger inlet and outlet connections.
   5. Install pressure-relief valves on heat-exchanger shells where a connection has been provided on shell. When no shell pressure-relief valve connection has been provided, install pressure-relief valve on shell outlet piping before any isolation valves.
   6. Install pressure-relief valves on heat-exchanger tube outlet piping before any isolation valves.
   7. Pipe pressure-relief valves, full size of valve connection, to floor drain.
   8. Install hose end valve to drain shell.
   9. Install thermometer on each heat-exchanger fluid outlet piping.

10. Install pressure gauges on each heat-exchanger fluid outlet piping and steam inlet piping.
11. Install vacuum breaker at heat-exchanger steam inlet connection.

## 3.3 CLEANING AND PROTECTION

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. Isolate heat exchangers from piping before flushing piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blind flanges in flanged joints to isolate equipment.

C. Flush heat-exchanger piping systems with clean water; then remove and clean or replace strainer screens before reopening flow to heat exchangers.

END OF SECTION 23 57 00

# SECTION 23 73 00 – CENTRAL STATION AIR HANDLING UNITS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Modular double wall air handling units

B. Related Requirements:

1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## 2.2 MODULAR DOUBLE WALL AIR HANDLING UNITS

A. Furnish and install air handling units as specified below, and as described in diagrams and schedules on the drawings. The unit shall include frame casing, insulated drain pans, heating and cooling coils, fan assemblies, access panels for easy access to all service points, bearings, motors and drives and guards.

B. The units shall be constructed of welded or bolted angle or channel steel frames. The entire frame assembly shall be hot dipped galvanized after fabrication, or suitably treated with a rust inhibitor coating. The casing shall be 2-inch solid double wall G90 galvanized metal with foam injected panels. The casing shall be rated per ASHRAE/ANSI 1350 to meet or exceed the following: L/240 deflection at 8" positive and negative pressures – Class CD2; Class CL6 Leakage at 8" positive and negative pressures; R-13 Class CT1; Thermal bridging Class CB0. Hinged access doors with camlocks and heavy duty hinges shall be provided for ready access to bearings, motors, drives, coils, piping devices and connections, and other points required for maintenance service or inspection. Condensate drain pans shall be installed with 2" of insulation provided between the drain pan and the casing and shall drain both the coil and the fan; units with multiple vertically stacked coils shall have an intermediate drain pan. The pans shall be of continuously welded seams, Series 300 stainless steel construction, 'V' shaped and/or sloping to the drain connection, flat pans will not be acceptable. Drain pans shall be located in the coil section and in the fan section.

C. Indoor units: Entire air handling unit shall set on base rails to allow deep condensate trap and where shown on the plans extended base rails shall be provided to support external filter housing and sheet metal transitions. Base rails shall be a minimum of 6" height where no size is indicated on the plans.

D. Outdoor units: Roof shall be cross-broken and pitched with "C" caps over joints to provide watertight seal.

E. Outdoor units: Roof mounted air handling units shall include unit attached perforated sliding metal screens to conceal and access the air handling unit.
1. Metal panels to be constructed of extruded aluminum.
2. Perforated metal panels to include a minimum open area of 20%.
3. Perforated metal panels shall include a rib design, similar to CityScapes model Vertical 7.2 Rib Perforated.

F. Fans shall have capacities and minimum wheel diameters as indicated on the schedules. Each fan shall be of the non- overloading centrifugal type with deep drawn inlet rings, streamlined housing and scroll, with blades continuously welded to the flange, solid backplate, full curved shroud, and flanged discharge collar. Where Class II construction is required, wheels shall be reinforced with a welded intermediate ring. Fan bearings shall be heavy duty, self-aligning, grease lubricated, antifriction type with double row rollers and labyrinth grease seals. Grease fittings shall be extended through the unit housing. Provide drain openings at the bottom of each fan scroll. Each fan shall be equipped with an adjustable pitch V-belt drive selected for 1.5 times the motor horsepower, motor slide-rail base and drip-proof motor. Fans and motors shall be resiliently mounted on a single structural base, internally mounted with resilient mounts on the unit structural frame. Fans shall be airfoil or backward inclined as scheduled. Forward curved fans may be used only where specifically scheduled. Internal resilient mounting shall be spring type with minimum 1-1/2" static deflection and provided with seismic restraints.

G. Manufacturer shall use the most energy efficient fan option within the manufacturer's line for the unit size but in no case will the wheel be smaller than the diameters scheduled.

H. The units shall be provided with coils of the types and capacities scheduled. Cooling coil casing shall be Series 300 stainless steel, others shall be galvanized steel. Coils shall be constructed with no less than ½” diameter x .020” wall thickness copper tubes and .0075” aluminum or copper fins spaced not closer than 8 per inch. Fins shall be permanently secured to the tubes by mechanical bonding or soldering and shall be plate type. Frame shall be shall include intermediate tube supports to prevent sagging of the tubes. The coil shall be removable with removing casing panels (i.e., casing shall have its own internal frame and shall not use the coil for support).

I. Water coil headers and “U” bends shall be arranged so that the entrained air is carried along with the flow of water through the coil to the high point on the leaving water header. High points in the coil shall be provided with vent connections. Multi-row coils shall be arranged for counterflow heat exchange between the air and water. Coil connections shall be red brass with NPT ends.

J. Steam coils shall be one pass (opposite and connections) non-freeze distributing tube type with concentric steam supply and condensate return tubes. Inner steam supply tubes shall have orifices for even distribution of steam. Preheat steam coils shall include integrated face and bypass for freeze protection.

K. Manufacturers: JCI, Trane

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

A. Furnish and install air handling units as shown and scheduled on the drawings.

B. Equipment Mounting:
   1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided.
   2. Comply with requirements for vibration isolation and seismic-control devices specified.

C. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

F. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

G. Coordinate duct installations and specialty arrangements with schematics.

H. Connect duct to air-handling units with flexible connections.

I. Coordinate roof mounted air handling unit screens with all other equipment on the roof. Architect to select final color/finish of sliding screening panels.

## 3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Steam and Condensate Piping: Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

## 3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Division 26.

B. Ground equipment according to Division 26.

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

## 3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Divisions 25 and 26.

## 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. Verify that shipping, blocking, and bracing are removed.
   3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
   4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
   6. Verify that zone dampers fully open and close for each zone.
   7. Verify that face-and-bypass dampers provide full face flow.
   8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
   9. Comb coil fins for parallel orientation.
   10. Verify that proper thermal-overload protection is installed for electric coils.
   11. Install new, clean filters.
   12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:
   1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
   2. Measure and record motor electrical values for voltage and amperage.
   3. Manually operate dampers from fully closed to fully open position and record fan performance.

## 3.7 CLEANING AND PROTECTION

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

## 3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 00

# SECTION 23 82 00 – CONVECTION HEATING AND COOLING UNITS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. **Variable volume terminal unit**
   2. **Duct-mounted hot water reheat coils**
   3. **Duct-mounted electric reheat coils**
   4. **Fan-coil units**
   5. **Blower-coil units**
   6. **Hot water unit heaters**
   7. **Electric unit heaters**
   8. **Terminal unit coil hookup**

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 VARIABLE VOLUME TERMINAL UNIT WITH HOT WATER HEAT

A. Unit casing shall be welded, galvanized steel. Leak rate shall be not more than 1% of rated capacity at 4” wg. Interior surface of unit casing shall be acoustically and thermally lined with 1/2 inch thick, minimum of 1.5 lb./cu. ft. density glass fiber with foil face. Insulation shall be UL listed and meets NFPA-90A and UL 181. Factory mounted, removable panel on bottom of unit providing access to air valve and entering airside of coil. Straight flange or slip and drive rectangular discharge duct connection.

B. Air valve shall be a 90° rotational damper flow control device with factory installed direct digital controls (DDC). All controls shall be furnished under Division 25 and mounted and wired in the factory by unit manufacturer. Manufacturer shall provide multiple point averaging flow sensing ring with high and low pressure pneumatic tubes compatible with DDC velocity pressure sensor. A calibration chart shall be provided on each unit.

C. At the Contractor’s option Division 25 may field mount controls at no additional cost to the Owner.

D. Factory mounted one, two, or three water row coil with maximum of 12 fins per inch. Full fin collars for accurate fin spacing and maximum tube-fin contact, 5/8 inch O.D. seamless copper tubes mechanically expanded into the fin collars, leak tested at 300 psig.

E. Factory mounted electric coil
   1. Line terminal block
   2. Control terminal block
   3. Nickel chrome heating element
   4. ETL listed
   5. Differential pressure airflow switch
   6. Safeties
      a. Primary automatic reset thermal cutout
      b. Secondary manual reset thermal cutout
   7. SCR controller

F. Manufacturers: Titus, Anemostat, Carnes, Enviro-Tech, Krueger Metal Aire, Nailor, Price, Trane, Tuttle and Bailey, Greenheck, or Approved equivalent.

## 2.3 DUCT MOUNTED HOT WATER REHEAT COILS

A. Hot water reheat coil casings shall be galvanized steel. Coils shall be constructed with no less than ½” diameter x .020” wall thickness copper tubes and .0075” aluminum or copper fins spaced not closer than indicated on equipment schedule. Fins shall be permanently secured to the tubes by mechanical bonding or soldering and shall be plate type. Frame shall include intermediate tube supports to prevent sagging of the tubes.

B. Headers and “U” bends shall be arranged so that the entrained air is carried along with the flow of water through the coil to the high point on the leaving water header. High points in the coil shall be provided with vent connections. Multi-row coils shall be arranged for counterflow heat exchange between the air and water.

C. Coils performance shall be AHRI 410 certified. Submittals shall include AHRI certified reference number.

D. Manufacturers: Daikin, Heatcraft, Marlo, Precision Coil, Super Radiator Coils, Technical Systems, Temtrol, Trane, USA Coil, or Approved equivalent.

## 2.4 DUCT MOUNTED ELECTRIC REHEAT COILS

A. Elements shall be made of high quality alloy resistor wire, centered and permanently encased with highly compacted, rockhard refractory material, surrounded by steel sheath. Helical fins shall be furnace brazed to the sheath for rapid head transfer. Sheath and fins shall be coated with a high temperature fired ceramic for corrosion resistance

B. Units shall have primary over temperature protection, secondary over temperature protection, and overcurrent protection all mounted in an enclosed control cabinet mounted on the units.

C. Manufacturers: Markel Series CHMS, Greenheck, Indeeco, Marley, Nailor, Wattco, or Approved equivalent.

## 2.5 FAN COIL UNITS

A. The basic unit shall be constructed of galvanized steel and insulated to meet the ARI Fan-Coil Industry test standard for insulation efficiency. Coils, motor speed control, electric junction box, primary and auxiliary drain pans, motor board, motor(s), and fan(s) shall be included in the basic unit.

1. Exposed wiring shall be in flexible conduit. Unit mounted electrical devices shall be prewired to a junction box. Units shall comply with Underwriters' Laboratories standard No. 883 for Room Fan Coil Units. All unit/cabinet styles: shall have a factory installed and wired disconnect switch. Disconnect switch shall be Hubbell model HBL-1221 or equivalent.
2. Unit shall have an externally insulated stainless steel condensate drain pan/trough. An auxiliary drain pan located in end pocket shall be molded plastic. Drain surfaces shall be separate from the motor board assembly.
3. Insulation shall be 1/2" thick, 2 lb. density, foil faced fiberglass with no exposed fiberglass to the air stream.
4. Motors and fans shall be mounted on a removable galvanized steel motor board assembly. Wiring shall have a modular plug to allow removal of the motor board from the unit without tools.
5. Fan wheels shall be metal centrifugal forward curve type, dynamically balanced. Fan housing shall be constructed of galvanized steel with streamlined air inlets.

B. Coils

1. Cooling coils shall be constructed of 1/2" O.D. seamless copper tubes mechanically bonded to aluminum fins. The entire coil assembly shall be factory tested with 300 psig air pressure when the coil is submerged in warm water. It shall have a maximum working pressure of 200 psig. Each coil shall be provided with a manual air vent.
2. Auxiliary heating coils shall be constructed of 1/2" O.D. seamless copper tubes mechanically bonded to aluminum fins. The coils shall be tested at 300 psig air pressure under warm water, and shall have a maximum working pressure of 200 psig. Each coil shall be provided with a manual air vent.

C. Motors shall be resilient mounted, permanent split capacitor, totally enclosed, tap wound for 3-speed, with integral thermal overload protection and automatic reset. Minimum power factor shall be .96. Motors shall be permanently lubricated with provision for re-oiling. High static motors shall be provided as scheduled or as need to meet the scheduled performance.

D. Exposed floor mounted cabinets:
1. Cabinets shall be constructed with 16 gauge steel fronts, tops, and end panels. Cabinet shall have 18 gauge back panel. Fronts, backs, sides, and top panels forming the air flow path shall be insulated for maximum thermal and acoustical performance. Cabinet parts shall be cleaned and phosphatized before painting.
2. Cabinets shall have extended 9" end pockets on both sides.
3. Front panels shall be one piece, tamper proof, secured to the unit without visible fasteners. Units shall have four leveling bolts.
4. The finish shall be baked enamel with color selected by Architect, from the manufacturer's standard colors.
5. Units shall have stamped steel supply grille.
6. Factory Controls: Factory furnished and wired, unit mounted thermostat/controller with integral fan speed and sequenced heating and cooling. Furnish, install, and wire electric modulating control valves.

E. Exposed horizontal cabinets and Ceiling Recessed Units:
1. Cabinets shall be constructed with 16 gauge steel panels. Fronts, backs, sides, and top panels forming the air flow path shall be insulated for maximum thermal and acoustical performance. Cabinet parts shall be cleaned and phosphatized before painting.
2. The finish shall be baked enamel with color selected by Architect, from the manufacturer's standard colors.
3. Cabinets shall have extended 9" end pockets on both sides. Bottom panels shall be one piece, hinged, with tamper proof fasteners.
4. Units shall have stamped angled louvers, both for inlet and outlet.
5. Factory Controls: Factory furnished, field installed, remote mounted thermostat/controller with integral fan speed, automatic change over and sequenced heating and cooling for modulating control valves.

F. Concealed Units
1. Casing shall be constructed of 18 gauge panels. Units shall be furnished with inlet and outlet duct collars, and vibration isolation grommets.
2. Factory Controls: Factory furnished, field installed, remote mounted thermostat/controller with integral fan speed, automatic change over and sequenced heating and cooling for modulating control valves.
3. Wall Recessed Units:
4. Cabinets shall have a one-piece 16-ga. steel front panel with stamped angled louvers, both for inlet and outlet. Cabinet shall be galvanized front and back with baked enamel finish in a color chosen by the Architect. Cabinet shall be airtight at all seams including wall to unit seal to prevent smudging. Cabinet shall be provided with tamper proof access panels.
5. Factory Controls: Factory furnished and wired, unit mounted thermostat/controller with integral fan speed and sequenced heating and cooling. Furnish, install, and wire electric modulating control valves.
6. Filters shall be 1" pleated fiberglass media 30% (MERV 7) throw-away filters. Furnish and install one complete set of filters for start-up and one complete set of filters following substantial completion and acceptance.

G. Manufacturers: Trane, Airtherm, Engineered Air, Superior Rex, or Approved equivalent.

## 2.6 BLOWER COIL UNITS

A. The basic unit shall be constructed of galvanized steel and insulated to meet the ARI Fan-Coil Industry test standard for insulation efficiency. Coils, motor speed control, electric junction box, primary and auxiliary drain pans, motor board, motor(s), and fan(s) shall be included in the basic unit.

1. Exposed wiring shall be in flexible conduit. Unit mounted electrical devices shall be prewired to a junction box. Units shall comply with Underwriters' Laboratories standard No. 883 for Room Fan Coil Units. All unit/cabinet styles: shall have a factory installed and wired disconnect switch. Disconnect switch shall be Hubbell model HBL-1221 or equivalent.
2. Unit shall have an externally insulated stainless steel condensate drain pan/trough. An auxiliary drain pan located in end pocket shall be molded plastic. Drain surfaces shall be separate from the motor board assembly.
3. Insulation shall be 1/2" thick, 2 lb. density, foil faced fiberglass with no exposed fiberglass to the air stream.
4. Motors and fans shall be mounted on a removable galvanized steel motor board assembly. Wiring shall have a modular plug to allow removal of the motor board from the unit without tools.
5. Fan wheels shall be metal centrifugal forward curve type, dynamically balanced. Fan housing shall be constructed of galvanized steel with streamlined air inlets.

B. Coils

1. Cooling coils shall be constructed of 1/2" O.D. seamless copper tubes mechanically bonded to aluminum fins. The entire coil assembly shall be factory tested with 300 psig air pressure when the coil is submerged in warm water. It shall have a maximum working pressure of 200 psig. Each coil shall be provided with a manual air vent.
2. Auxiliary heating coils shall be constructed of 1/2" O.D. seamless copper tubes mechanically bonded to aluminum fins. The coils shall be tested at 300 psig air pressure under warm water, and shall have a maximum working pressure of 200 psig. Each coil shall be provided with a manual air vent.

C. Motors shall be resilient mounted, permanent split capacitor, totally enclosed, tap wound for 3-speed, with integral thermal overload protection and automatic reset. Minimum power factor shall be .96. Motors shall be permanently lubricated with provision for re-oiling. High static motors shall be provided as scheduled or as need to meet the scheduled performance.

D. Concealed Units

1. Casing shall be constructed of 18 gauge panels. Units shall be furnished with inlet and outlet duct collars, and vibration isolation grommets.
2. Factory Controls: Factory furnished, field installed, remote mounted thermostat/controller with integral fan speed, automatic change over and sequenced heating and cooling for modulating control valves.
3. Cabinets shall have a one-piece 16-ga. steel front panel with stamped angled louvers, both for inlet and outlet. Cabinet shall be galvanized front and back with baked enamel finish in a color chosen by the Architect. Cabinet shall be airtight at all seams including wall to unit seal to prevent smudging. Cabinet shall be provided with tamper proof access panels.

4. Factory Controls: Factory furnished and wired, unit mounted thermostat/controller with integral fan speed and sequenced heating and cooling. Furnish, install, and wire electric modulating control valves.
5. Filters shall be 1” pleated fiberglass media 30% (MERV 7) throw-away filters. Furnish and install one complete set of filters for start-up and one complete set of filters following substantial completion and acceptance.

E. Manufacturers: Trane, Airtherm, Engineered Air, Superior Rex, or Approved equivalent.

## 2.7 HOT WATER UNIT HEATERS

A. Cabinet type units shall include a 16 gauge furniture steel casing, inclined blade type inlet and discharge grilles, removable panels, 120/1/60 fan motors, quiet operating centrifugal fans, non-ferrous hot water heating coils, throwaway filters, vandal proof fasteners, and air vent tappings. The heaters shall be arranged for mounting as indicated. Heater casings shall be finished in baked enamel with colors as selected by the Architect/Engineer.
   1. Manufacturers: Trane Force Flow, Sterling, Airtherm, Daikin, Engineered Air. Enviro-tec, Rittling, or Approved equivalent.

B. Propeller type units shall have a heavy gauge enameled steel casing, deep pitch propeller fan direct connected to a resiliently mounted capacitor start squirrel cage induction motor 120/1/60, adjustable discharge louvers, fan guard, non-ferrous hot water heating coil with supply and return connection in rear of unit, arranged for hanging from top side hanger rod connections, and finished in the manufacturer's standard color baked enamel finish.
   1. Manufacturers: Trane Model S, Airtherm Model HU, or Vulcan Model HV, Sterling Model HS, or Approved equivalent

## 2.8 ELECTRIC UNIT HEATERS

A. Cabinet type units shall include a 16 gauge furniture steel casing, inclined blade type inlet and discharge grilles, removable panels, 120/1/60 fan motors, quiet operating centrifugal fans, nickel chrome heating coils, throwaway filters, vandal proof fasteners, and air vent tappings. The heaters shall be arranged for mounting as indicated. Heater casings shall be finished in baked enamel with colors as selected by the Architect/Engineer.

B. Propeller type units shall have a heavy gauge enameled steel casing, deep pitch propeller fan direct connected to a resiliently mounted capacitor start squirrel cage induction motor 120/1/60, adjustable discharge louvers, fan guard, nickel chrome heating coil with supply and return connection in rear of unit, arranged for hanging from top side hanger rod connections, and finished in the manufacturer's standard color baked enamel finish.

C. Unit shall be provided with safety thermal cutouts, fan delay control relay, and built-in thermostat, remote wall thermostat or BAS connection as scheduled.

D. Manufacturers: Indeeco, Marley, Modine, QMark, Reznor, Trane, or Approved equivalent.

## 2.9 TERMINAL COIL HOOKUP

A. Contractor to provide valves and specialties specified herein and in section 20 10 13 Valves (not valves from a HVAC hose kit manufacturer). Two service valves and a manual balance valve are require regardless of memory function of balance valves.

B. One of the following piping and specialty configurations is acceptable (piping components installed in the order listed):
   1. Supply service valve, balance valve, tee with integral drain, hard pipe or hose to coil, hard pipe or hose from the coil, tee with integral vent, control valve, service valve.
   2. Supply service valve with integral drain (on coil side), balance valve, hard pipe or hose to coil, hard pipe or hose from the coil, control valve, service valve with integral vent (on coil side).

C. When hoses are used at the contractors option they shall meet the following:
   1. Internal diameter of the hose shall be not less than 90% of the ID of copper pipe, for the pipe size on the drawings feeding the unit. Hose inner liner shall be EDPM rubber and shall be covered with stainless steel braid. Pressure rating shall not be less than 200 psig.
   2. Hoses shall have one fixed end male NPT connection and one swivel end. The swivel shall be a gasket-less JIC 37°F flared female connection, with companion flare x NPT fitting. Connections shall be stainless steel or brass. Hose kits shall be 24” long. Hoses using gaskets or o-rings are not acceptable.
   3. Manufacturers: Twin City Hose, ACE Hose, Hosecraft USA, Chamflex, or approved equivalent meeting the above specifications.

D. Specialty Valves incorporating auxiliary ports for p/t, drain, vent, etc. may be utilized provided the arrangement meets the flow diagram and the products do not contain unions, gaskets, or o-rings. Valves shall be dezincification resistant brass and shall be rated for 200psig minimum at 200°F.
   1. Service valve with integral drain /vent. Webstone Ball Drain, Cimberio Valve model 630B less strainer basket, or approved equivalent.
   2. Service valve with NPT tapping, plus separate drain cocks. Apollo 7B-100, Cimberio 200MC, or approved equivalent.
   3. Tee with integral drain /vent. Webstone T-drain, or approved equivalent.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to receive radiators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

C. Examine roughing-in for hydronic-piping and electrical connections to verify actual locations before installation of terminal units.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Variable volume terminal units
1. Furnish and install terminal units of the size and capacities as indicated on the drawings.
2. Install air terminal units according to NFPA 90A.
3. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
4. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
5. See piping details for required valves and accessories.

B. Duct mounted hot water reheat coils
1. Furnish and install duct heaters of the size and capacities as indicated on the drawings.
2. Install coils level and plumb.
3. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
4. Straighten bent fins on air coils.
5. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.
6. Install piping adjacent to coils to allow service and maintenance.
7. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

C. Duct-mounted electric reheat coils
1. Furnish and install duct heaters of the size and capacities as indicated on the drawings.
2. Install coils level and plumb.
3. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
4. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.
5. Connect wiring and ground equipment per Division 26.
6. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
7. Install control and electrical power wiring to field-mounted control devices.

D. Fan coil units, Blower coil units, and unit heaters
1. Furnish and install fan coil units and unit heaters of types, arrangements, and capacities as indicated on the drawings.
2. Install units to comply with NFPA 90A.
3. Install units level and plumb.
4. Suspend units from structure with all-thread hanger rods and spring hangers.
5. Install wall-mounted thermostats and switch controls in electrical outlet boxes. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
6. Install new filters in each unit within two weeks after Substantial Completion.

**END OF SECTION 23 82 00**

# SECTION 23 83 00 – AIR COMPRESSOR

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. **Air Compressors**

B. Related Requirements:
   1. Section 23 00 00 HVAC Piping and Equipment

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 AIR COMPRESSOR (SCENE SHOP)

A. Air compressor shall be a vertical style with a two-stage pump capable of delivering a maximum airflow of 40 SCFM at 90 PSI with a maximum cut-out pressure of 175 PSI.

B. The compressor shall include a single (1) 120 gallons steel tank.

C. Compressor motor shall be a 10 HP, 3-phase TEFC induction motor.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

## 3.2 INSTALLATION

A. Furnish and install air compressor as scheduled and shown on drawings.

END OF SECTION 23 83 00

# SECTION 24 00 00 – AIR DISTRIBUTION

## 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. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 24 of these Specifications.
1. Section 24 31 00 – Sheetmetal Ductwork
2. Section 24 33 00 – Air Duct Accessories
3. Section 24 33 50 – Internal Acoustical Duct Lining
4. Section 24 34 00 – Fans
5. Section 24 36 00 – Dust Collection System
6. Section 24 37 00 – Air Devices
7. Section 24 38 10 – Type I Hoods
8. Section 24 41 00 – Filter Assemblies

C. The following sections of the Specifications apply to Work under this Section
1. Division 20 - Basic Mechanical, Plumbing, and Fire Protection
2. Division 23 – HVAC Piping and Equipment
3. Division 25 – Temperature Controls

### 1.2 SUMMARY

A. Section Includes:

1. Sheetmetal ducts, sheet metal plenums, duct linings, flexible ductwork, dampers, and accessories.
2. Louvers and louvered penthouses.
3. Fans and accessories.
4. Air Devices, including adjusting the pattern controllers.
5. Dust Collection System and accessories.
6. Type I hoods and accessories.
7. Filters and accessories.
8. Installation of all mentioned above.
9. Smoke stopping of all penetrations of ductwork and firestopping through fire rated partitions as shown on architectural drawing.

### 1.3 REFERENCES

A. Applicable requirements of the current and accepted edition of the following industry standards, codes and specifications shall apply to the Work for Division 22
1. ASHRAE, “Handbook 1997 Fundamentals”; Chapter 32 - Duct Design.

2. ASHRAE, "Handbook 1996 Equipment"; Chapter 16 - Duct Construction.
3. ASTM A90-81 (1991), "Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles".
4. ASTM A525-91b, "Spec for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process".
5. ASTM A527/A527M-90, "Spec for Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality".
6. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
7. SMACNA "HVAC Duct Construction Standard – Metal and Flexible" – Second Edition.
8. UL 33, "Heat Responsive Links for Fire Protection Service."
9. UL 555, "Fire Dampers and Ceiling Dampers."
10. UL 181, "Factory Made Air Ducts and Connectors."

1.4 DEFINITIONS

1. The size of the ducts shown on the drawings and in this Section of the Specifications shall be the outside dimension of the ductwork which will take into account any internal acoustical lining thickness specified for duct system or sub-system.
2. The term "supply air" where used in this Section of the Specifications shall mean downstream of a coil.
3. The term "outdoor air" where used in this Section of the Specifications shall mean ambient air that has not been conditioned.
4. The term "return air" where used in this Section of the Specifications shall mean conditioned air that is returned from the space.
5. The term "mixed air" where used in this Section of the Specifications shall mean air streams that are a mixture of "outdoor air" and "return air".
6. The term "relief air" where used in this Section of the Specifications shall mean excess return air that relieved from the building.
7. The term "exhaust air" where used in this Section of the Specifications shall mean air that is removed due to contaminates, odors, or heat.

1.5 QUALITY ASSURANCE

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20.

B. Gaskets containing asbestos are not acceptable.

C. Where duct and accessories installed under this section of the specification tie-in to existing systems, Contractor shall verify existing for: sizes, direction of flow (via pressure or physical tracing of piping, not labels), materials, and elevations before installing new work. Contractor shall notify Architect/Engineer upon discovery of discrepancy. Work performed prior to verification will be corrected at no cost to Owner.

## 1.6 ACTION SUBMITTALS

A. Contractor shall submit coordination drawings to the Engineer for review prior to any fabrication or installation. (Refer to Section 20 10 00).

B. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

## 1.7 INFORMATIONAL SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 24.

## 1.8 CLOSEOUT SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 24.

B. At the completion of the project, submit a letter stating all materials are asbestos free, and meet the specified ASTM E-84 flame/smoke rating of 25/50, and that all piping and duct penetrations are smoke or fire stopped as required by the Code.

## PART 2 - PRODUCTS (Not Applicable)

## PART 3 - EXECUTION (Not Applicable)

END OF SECTION 24 00 00

# SECTION 24 31 00 – SHEETMETAL DUCTWORK

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings
   2. Single-wall round ducts and fittings.
   3. Sheet metal materials.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Refer to Division 20 for seismic delegated design requirements.

## 2.2 MATERIAL

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel:
   1. Comply with ASTM A653/A653M.
   2. Galvanized Coating Designation: G90.
   3. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless Steel Sheets:
   1. Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article.
   2. Cold rolled, annealed, sheet.
   3. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

## 2.3 CONSTRUCTION

A. General Construction Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for material thicknesses, and construction methods unless otherwise indicated.
   1. Where local code requires gauges heavier than required by SMACNA then the local code shall govern.

B. All rectangular ducts unless specified otherwise shall be “Pittsburgh Lock” longitudinal joints. Snaplock is not acceptable.

C. All round ducts and flat oval ducts shall have spiral seams or continuously welded longitudinal seams.
   1. Round ductwork where scheduled or where indicated on the plans shall be K-27 double wall internally insulated for sound control and/or thermal performance.

D. All transverse joints in rectangular ductwork 24” and larger shall be Ductmate, SMACNA T-25, or approved equivalent. All flanged ductwork, regardless of pressure class, shall use gaskets, corner closures, and be TEK screwed or riveted on 10” centers with a minimum of two (2) per side. Transverse joints in rectangular ductwork smaller than 24” shall be made in accordance with SMACNA suitable with the pressure class.

E. All transverse joints in round and oval ductwork 24” and larger shall be Ductmate, or approved equivalent. Transverse joints in round and overall ductwork smaller than 24” shall be beaded sleeve joints.

F. Panels in all ducts 12” and larger shall be cross-broken or beaded on 12” centers.

G. Dust collection ductwork:
   1. Diameters 3" - 24" Quick-Fit pipe, adjustable nipples, and collars attached to other components will have one or both ends die formed-rolled to provide a uniform edge around

the circumference of the rolled end. The pipe and adjustable nipples shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system. Pipe lengths using laser welded seams will not exceed a nominal 60" length. The rolled edges provide structural support at 5' intervals or less and can be interpreted as a stiffener where SMACNA specifications are required. An adjustable nipple is used for adjustment during the install process. Pipe is cut to appropriate length and the adjustable nipple secures the pipe for install.

2. Quick-Fit pipe and components larger than 24" shall utilize either an angle flange or flat flange attached loosely and retained in place using a 3/8" Vanstone lip. The flanged pipe shall have a solid welded seam and not exceed nominal 60" length. The angle or flat flanges provide structural support at 5' intervals or less and are considered as stiffeners where SMACNA specifications are required.
3. Ducting and its components shall be factory tested to +/- 80" WG on pipe diameters 3" to 20" and will use 22 gauge material thickness for 3” to 12” duct and 20 gauge for larger ducts.
4. Rolled edge duct clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.
5. Metal-to-metal contact shall be obtained at all joint connections. Die-formed rolled edges are uniform in shape to provide the most consistent contact. The ears of the clamp contact with the rolled edges and provide maximum conductivity. Conductivity shall be adhered to per NFPA 77 paragraph 8.4.1.1; states all parts of the continuous metal piping system should have a resistance level that does not exceed 10 ohms. Contractor shall field test resistivity.
6. Dust collection ductwork shall be Nordfab Quick-Fit pipe or approved equivalent. Layout shall be factory designed and submit as shop drawing

2.4 SEALING

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Sealing system components shall be water, mold and mildew resistant.

C. Dust collection ductwork:
   1. Approved caulk is 3M Scotch Seal Metal Sealant 2084 or equivalent for system temperatures of 250°F or lower.
   2. Sealing O-rings shall be Buna-N, ASTM D2000 MBC610, 60 Durometer Hardness, with a temperature rating of 250°F maximum and is black in color, used with the adjustable nipple.
   3. Sealing gaskets shall be molded and shall meet the material classification of ASTM D-2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 and used in systems where the temperature rating is 225°F or less and are black in color. This component shall be made using conductive materials for conductivity.
   4. Sponge O-ring shall meet the material classification of either ASTM D-1056-68 – SBE43 or ASTM D1056-85, 91, 98 – 2B3

5. Clamp seals shall be Nitrile to meet or exceed ASTM D1056 2B2 standards with a temperature rating not to exceed 158°F constant temperature (or intermittent temperature of 194°F).

## 2.5 FITTINGS

A. Rectangular duct branch take-offs, or rectangular to round, shall be 45°-boot fittings, spin in fittings are not acceptable.

B. Rectangular duct proportional splits shall be made the sizes as shown on the drawings. Where duct sizes are changed from the original design, Contractor shall proportion split equal to the split in airflow.

C. Rectangular duct changes in direction:
   1. 90 degree elbows, refer to plans, shall be mitered with turning vanes; or radiused with centerline radius to width ratio of 0.75 (inside radius/width ratio 0.25 with curve ratio 0.585) with 2 splitter vanes.
   2. 45 degree and less elbows shall be mitered without vanes.
   3. Elbows other than above shall be radiused with centerline radius to width ratio of 1 without splitter vanes.

D. Round elbows and changes in direction shall have a minimum centerline radius of 1-1/2 that of duct size. Round or oval branch take-off shall be 45 degree booted style similar to McGill Airflow Lo-Loss Tee.

## 2.6 PLENUMS

A. Sheetmetal plenums shall be constructed of a minimum of 18 ga. or greater as determined by the pressure class of the plenum. Sheetmetal and shall be braced and reinforced to support the weight of a 200-lb. person. Tie rods shall not be used.

B. Plenums shall be constructed without air turning vanes.

C. Plenums shall have access doors as sized on drawings, where no size is shown provide a minimum size of 18” x 36”. Comply with requirements in Section 243000 “Ductwork Accessories” for access door construction and installation requirements.

## 2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct." Under no case will less than double thickness 1” x #24-gauge galvanized metal be allowed. Cable hangers are not allowed.

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
  1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
  2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
  3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

## PART 3 - EXECUTION

### 3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. All ductwork shall be neatly constructed, stiffened, on the outside surfaces where necessary to prevent perceptible vibration or buckling. All ducts, housings, etc., shall be fabricated as detailed on the drawings and in the SMACNA Duct Construction Manual –Latest Edition.

C. All supply ductwork upstream of variable-air boxes, unless specified otherwise, shall be constructed of gauges and reinforcement to 4” w.g. static pressure in SMACNA Duct Construction Standard – Latest Edition.

D. All supply ductwork downstream of variable-air boxes, unless specified otherwise, shall be constructed of gauges and reinforcement to 3” w.g. static pressure in SMACNA Duct Construction Standard – Latest Edition.

E. All return, exhaust, outdoor air, relief, and supply ductwork downstream of terminal units shall be constructed of gauges and reinforcement to 3” w.g. static pressure in SMACNA Duct Construction Standard – Latest Edition. As a minimum, panels in all ducts 12” and larger shall be cross-broken or beaded on 12” centers.

F. Install ducts in maximum practical lengths with fewest possible joints.

G. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

K. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

L. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

M. Install fire dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 243000 "Ductwork Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

N. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

O. When approved by the Engineer ducts may be notched at structural steel. The converging angle shall be no greater than 30°, the diverging angle shall be no greater than 15°.

P. When approved by the Engineer objects may penetrate a duct. An airfoil shape shall be placed around the object to minimize turbulence.

Q. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

## 3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

## 3.3 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to be welded. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
1. Ductwork is to be galvanized steel.
2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

## 3.4 PATTERN HOLE DUCTWORK

A. Install ducts in Supply air for the Black Box theater in the Art Annex building shall be distributed through low-velocity patterned hole ductwork. Locations of this type of ductwork are identified on the drawings.

B. Patterned hole ductwork shall consist of an assembly of round spiral ductwork with field-installed 1” thick slide-in acoustic liner. Ductwork shall be paint grip galvanized finish in anticipation of field-applied painting. See section 24 31 00 for details about construction of the ductwork and section 24 33 50 for details about the acoustic duct liner.

C. Procedure for assembly and installation of the patterned hole ductwork shall be as follows:
1. Clean spiral ductwork. See section 24 00 08 for duct cleaning requirements.
2. Install duct liner in ductwork. Follow manufacturer’s instructions for a standard install in round spiral ductwork.
3. Cut holes through ductwork and liner, with the pattern following that on the mechanical details sheet (three rows of 4” holes – one row running along the top of the duct and the other two rows running 45° off top center). Avoid ribs in ductwork to ensure structural stability. The self-applied radial pressure of the duct liner should allow it to be cut post-installation in the ductwork.
4. After the holes are cut, the ductwork shall again be thoroughly cleaned and vacuumed out to remove any dust particles.
5. Apply dark gray or black mastic sealant to cut surface of holes to holes to prevent future fraying of duct liner.
6. Temporarily cover holes in ductwork using airtight covers.
7. Install ductwork. Ductwork shall not be used for temporary conditioning of the space for construction purposes.
8. Paint ductwork according to section 20 10 75 (dry-fall paint, black). Do not complete this step until the exterior walls of the building have been closed up, and dust has been removed from the space.
9. Remove hole covers and inspect ductwork for any necessary touch-ups.

## 3.5 SEALING

A. Duct sealant shall be flexible, water-based, adhesive sealant designed for use in 4” static pressure systems. Sealer shall be UL listed and conform to ASTM E84. Sealer shall be equal to Ductmate PROseal, United McGill Uni-Mastic, Duro-Dyne DSW, or equivalent.

B. All supply ductwork unless specified otherwise shall be SMACNA's seal class A.

C. All return, exhaust, outdoor air, relief and supply ductwork downstream of terminal units shall be SMACNA's seal class B.

## 3.6 SURFACE PREPARATION FOR PAINTED DUCTWORK

A. Contractor shall inspect all exposed ductwork for damage, dents, and out of roundness. Replace all imperfect ductwork.

B. Ductwork shall be sealed, tested (where applicable) and cleaned thoroughly prior to painting.

C. Galvanized ductwork that is to be painted shall be installed with paintgrip galvanized finish.

## 3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Hangers Exposed to View: Threaded rod and angle.

C. Ducts that are to be externally insulated shall not be supported on unistrut channel unless it required based upon loading. Hanger rods for trapeze bars shall be spaced to allow for insulation installation.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

## 3.8 DUCTWORK CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

## 3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

## 3.10 CLEANING AND PROTECTION

A. Contractor shall implement procedures to maintain an “Advanced Level’ of ductwork cleanliness per the latest addition of the SMACNA Duct Cleanliness for New Construction Guidelines.
   1. Production and Site Delivery:
      a. Self-adhesive labels for part of identification are to be applied to the external surfaces only.

b. During transportation, ductwork and air distribution components shall be sealed either by blanketing or capping the duct ends, bagging small fittings, surface wrapping or shrink wrapping.

2. Site Storage:
   a. Temporary storage shall be located away from high dust generating processes such as masonry, tile cutters, saws, drywall sanding, mortar and plaster mixers, roof pitch kettles, portable electric generators, and main walkways that will be constantly broom swept.
   b. Temporary storage shall include pallets or blocking to keep ductwork and air distribution components above floor surface to prevent water damage.
   c. Coverage should be used to protect stored materials at all times.
   d. Duct open ends and air side of air distribution components shall be securely sealed at all times.
   e. Seals shall be visually examined and if damaged, resealed with an appropriate material.
3. Installation:
   a. Before installation of individual duct sections and air distribution components, they are to be inspected to ensure that they are free from debris and shall be wiped clean if debris exists.
   b. The working area shall be clean, dry, and the airside of ductwork and air distribution components protected from dust and moisture.
   c. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.
   d. Open ends on completed ductwork shall be sealed immediately if left for an extended period of time (work breaks, overnight, etc.).
4. Clean new duct system(s) before testing, adjusting, and balancing.
5. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."
6. Use service openings for entry and inspection.
   a. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
   b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   c. Remove and reinstall ceiling to gain access during the cleaning process.
7. Particulate Collection and Odor Control:
   a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
8. Clean the following components by removing surface contaminants and deposits:
   a. Air outlets and inlets (registers, grilles, and diffusers).
   b. 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.
   c. 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.
   d. Coils and related components.

e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
f. Supply-air ducts, dampers, actuators, and turning vanes.
g. Dedicated exhaust and ventilation components and makeup air systems.

9. Mechanical Cleaning Methodology:
   a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   b. 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.
   c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
   e. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
   f. Provide drainage and cleanup for wash-down procedures.
   g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

## 3.11 DUCT SCHEDULE

A. Fabricate ducts except as otherwise indicated shall be constructed from sheets or rolls of G-90 or better-galvanized steel. Fiberglass ductboard is prohibited.
   1. Ducts in interior exposed locations shall be constructed of paint-grip galvanized steel.

B. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

C. Supply ducts:
   1. Pressure Class: Positive 4 inch wg (Pa).
   2. Minimum SMACNA Seal Class: A.
   3. SMACNA Leakage Class for Rectangular: 4.
   4. SMACNA Leakage Class for Round and Flat Oval: 2.

D. Supply ducts downstream of terminal units:
   1. Pressure Class: Positive 3 inch wg.
   2. Minimum SMACNA Seal Class: B.
   3. SMACNA Leakage Class for Rectangular: 8.
   4. SMACNA Leakage Class for Round and Flat Oval: 4.

E. Return ducts:
   1. Pressure Class: Negative 3 inch wg.
   2. Minimum SMACNA Seal Class: B.
   3. SMACNA Leakage Class for Rectangular: 8.
   4. SMACNA Leakage Class for Round and Flat Oval: 4.

F. Exhaust ducts
1. Pressure Class: Negative 3 inch wg.
2. Minimum SMACNA Seal Class: B.
3. SMACNA Leakage Class for Rectangular: 8.
4. SMACNA Leakage Class for Round and Flat Oval: 4.
5. Exterior ducts:
    a. Aluminum
    b. No. 2D finish.
6. Paint booth exhaust from booths or hoods:
    a. 316 stainless steel OR
    b. Minimum SMACNA Seal Class A **OR** Welded seams and joints
7. Dust collection ductwork:
    a. Pressure Class: Negative 6” w.g.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 4.
    d. SMACNA Leakage Class for Round and Flat Oval: 2.
    e. All outdoor dust collection ductwork shall be 304SS: Finish meets ASTM A240. Temp rating is 1100°F.

END OF SECTION 24 31 00

# SECTION 24 33 00 – DUCTWORK ACCESSORIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Air Thermometers
   2. Dampers and Louvers
   3. Flexible Connectors
   4. Access Doors and Panels
   5. Flexible Ductwork
   6. Louvered Penthouses and Intake/Exhaust Hoods

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Dampers and Louvers: Air Balance, Arrow United, Greenheck, Nailor, NCA, Pottorff, or Ruskin.

B. Flexible connectors: Duro Dyne Corporation, Elgen, or Vent-Fabrics.

C. Access Doors and Panels: Ductmate, Greenheck, Nailor, Ruskin, or approved equivalent.

D. Flexible Ductwork: Flexmaster, Thermaflex, or approved equivalent.

E. Louvered penthouses and intake/exhaust hoods: Greenheck, Penn-Barry, Ruskin, United Enertech or approved equivalent.

2.3 AIR THERMOMETERS

A. Air thermometers shall be provided and in the supply air, coil discharge of all air handling unit coils, return air, mixed air, and outside air of the air handling units.

B. Airstream thermometers shall be bimetal type, with an accuracy of 1°F throughout the range with 5” dial size, 12” stem length, ½” N.P.T. back side connector with plain slip ring case of 304 stainless steel, and recalibrator. Thermometer shall be Trerice Model No. B85212 or approved equal as manufactured by Weksler, Marsh, or Marshalltown Instruments. Thermometers for use in the mixed air shall have flexible averaging elements strung with the mixed air temperature sensor and freezestat sensor elements. Mixed air thermometers shall be Trerice No. V80445 with bulb number 4-3-1.

C. Range shall be as follows:

| | |
|---|---|
| Outdoor air | -40-160°F |
| Mixed air | 0-100°F |
| Supply air | 25-125°F |
| Return air | 25-125°F |
| Preheat coil discharge | 25-125°F |
| Reheat coil discharge | 25-125°F |
| Chilled water coil discharge | 25-125°F |

2.4 BALANCING DAMPER

A. All dampers, except those located downstream from terminal units used to adjust individual grilles, shall have frames and bearings and shall have quadrant lock regulators with thread screw to allow damper to be securely locked into place.

B. Balancing dampers downstream from terminal units that are contractor fabricated or apart of manufactured branch fitting shall be a minimum of 18-ga. plate, 3/8” continuous square shaft with locking quadrant handle equal to Duro Dyne model Quadline. Duro Dyne model Duro-Twist, Rossi model Twistlock, or approved equivalent. Duro Dyne model Dyna-Click, Rossi model Everlock, or approved equivalent.

C. Rectangular dampers up to size 24” x 12” shall be Ruskin MD25, Nailor 1870, Arrow, Air Balance, NCA, or shop fabricated equal, approved by the Engineer.

D. Round dampers up to size 20” diameter shall be Ruskin MDRS25, Nailor 1890, Arrow, Air Balance, NCA or shop fabricated equal, approved by the Engineer.

E. Rectangular dampers larger than 24” x 12” shall be Ruskin MD35, Nailor 1820 or equivalent manufactured damper by NCA.

F. Where volume dampers are to be adjusted through walls or ceilings, such dampers shall be operated by regulators designed for recessed installation and provided with a cover plate which shall be flush to the surface of the wall or ceiling. Concealed regulators, as manufactured by Duro Dyne Corporation or Elgen shall be of the indicator type. The regulator shall be provided with a spring washer for non-binding adjustment and hex lock nut in addition to wedge pin which shall be installed to prevent damper rattle. Cast alloy regulator housing, with “open to shut” range positioning markers, shall be secured with removable cover to expose the regulator for adjustments.

## 2.5 CONTROL DAMPERS

A. All automatic dampers and control dampers shall be as specified in Division 25, “Temperature Control”. Dampers shall be furnished under Division 25 for installation under Division 23 30 00.

## 2.6 FIRE DAMPERS

A. Fire dampers shall be provided as indicated on the plans. Dampers shall be U.L. 555 listed under N.F.P.A. Pamphlet #90-A.
   1. Dampers for rectangular ductwork shall be Style B
   2. Dampers for round or oval ductwork shall be Style C.
   3. In both cases the curtain shall be located outside of the airstream.
   4. Factory wall sleeves are not permitted.
   5. Closure springs shall be furnished for both horizontal and vertical installations.

B. Dampers rated for installation in up to 2-hour fire resistive construction shall be Ruskin Type IBD2, Nailor model 0120/0130, Air Balance model 119, Greenheck model FD-150, or approved equivalent.

C. Fire dampers rated for installation in greater than 2-hour fire resistant construction shall be Ruskin Type IBD23, Nailor model 520/530, Air Balance model 319, Greenheck model FD-350, or approved equivalent.

## 2.7 AIR TURNING VANES

A. Furnish and install directional air turning vanes in ductwork at all 90 degree mitered elbows and 90 degree radiused elbows.

B. Mitered 90 degree elbows vanes shall be:
   1. Single rolled type with a radius of 2” with 1.5” spacing.
   2. Single rolled type with a radius of 4-1/2” with 3.25” spacing.
   3. Double thickness type with a radius of 4-1/2” with 3.25” spacing. Double thickness 2” radius is not allowed.
   4. Tie rods shall be used to limit the maximum unsupported width per the type of vane used per SMACNA.

5. Vanes shall be solidly installed and rattle-free locked into each slot of preformed vane guide rails as manufactured by Duro Dyne Corporation or Elgen. Rails shall be constructed of 24 gauge galvanized steel, specially embossed for extra strength and sturdiness.

## 2.8 FLEXIBLE CONNECTORS

A. Flexible connections shall be U.L. listed fabric that meets NFPA 90A. It shall weigh not less than 24 oz per sq. yd and have a tensile strength of not less than 500 psi. Flexible connections shall be preassembled “Super Metal-Fab” with 6” fabric attached to 3” metal on either side by means of “Grip-Loc” seam. At least one inch of slack shall be allowed when making connection to insure that no vibration is transmitted from fan to ductwork.
   1. Flexible connectors shall be No. MF6N as manufactured by Duro Dyne Corporation, or equivalent by Vent-Fabrics or Elgen.
   2. Flexible connectors for exposed interior ductwork shall be DuroDyne Insulflex or approved equivalent.
   3. Flexible connections on exterior ductwork shall be manufactured with DuroDyne Excelon fabric, Vent Fabrics Ventlon, or approved equivalent.

## 2.9 ACCESS DOORS and PANELS

A. 2” Pressure Class: Door shall be SMACNA Standard, 12” x 12”, double skin, 1” fiberglass insulation, with underside duct to frame gasket for reduced leakage.

   Solid without window Ruskin ADH22, Nailor 08SH, Greenheck HAD-10, Ductmate FDH, or equivalent.

B. 4” and Higher Pressure Class: Oval shape, ultra low leakage at 8” w.c.

   Solid without window Nailor 0800, Greenheck RAD, Ductmate Sandwich, or equivalent.

C. Access doors in casings and housings shall be fabricated double skin doors with 1” thick insulation between inner and outer surface as detailed in the SMACNA Duct Manual. Provide two compression latches equal to Ventlok #260 on each door. Where access doors provide for personnel entry into the system, they must be provided with inside/outside latch hardware. Provide access doors at all locations indicated on the drawings and into the mixing chamber of all air handling units. Size shall be 18 x 36, unless indicated otherwise on the drawings. Ruskin GPAD or equivalent.

D. For access panels required in ceiling, walls, etc. of the building construction, see Section 20 10 10.

## 2.10 FLEXIBLE DUCTWORK

A. Performance Requirements:
   1. Comply with NFPA 90A and NFPA 90B.
   2. Comply with U.L. 181
   3. Comply with ASTM E96/E96M.
   4. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise

indicated. Sheet metal materials must be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

5. Comply with the Air Duct Council's (formerly, Air Diffusion Council) "ADC Flexible Air Duct Test Code - FD 72-R1" and "Flexible Duct Performance & Installation Standards."
6. Comply with ASTM E96/E96M.

B. Construction:
1. Duct Fabric: A double lamination of tough polyester, which encapsulates a steel wire helix
2. Duct Helix: Spring steel galvanized helix.
3. Pressure rating: minimum of 6” w.g. positive and 0.5” w.g. negative.
4. Vapor barrier: Metallic
5. Insulation: Glass fiber, R-4.2 in Return Air Plenum, otherwise R-6
6. WARRANTY: minimum 5-year product warranty

C. Flexible duct shall be Flexmaster Type 9M, Thermaflex M-KE, or Approved equivalent.

## 2.11 INTAKE / EXHAUST HOOD

A. Intake/Exhaust hoods shall be heavy gauge aluminum construction with hinged hoods designed for intake or exhaust. All seams shall be continuously welded with lock formed seams. Hoods shall be stressed and sloped for drainage. Provide expanded aluminum birdscreen and roof curb to provide a height of 12” above the finished roof. Hood performance shall be based upon maximum inlet velocity of 600 fpm and a maximum pressure drop of .10” w.c., exhaust hoods shall have a maximum pressure drop of .15” w.c. The Contractors shall coordinate the curbs with the roof insulation thickness.

B. Hoods shall be Cook VI/VR, Penn-Barry Airette, Greenheck, United Enertech or equivalent.

C. Field fabricated exhaust goosenecks shall be aluminum construction with all joints sealed with an exterior sealant. The termination shall be a minimum of 18” above the roof. Provide expanded aluminum birdscreen.

## 2.12 WIND DRIVEN RAIN LOUVER

A. Louvers shall be high performance low pressure drop, low water penetration and drainable.

B. Louvers performance shall be AMCA Certified and shall meet or exceed the following specifications:
1. Based on testing 48 inches x 48 inches size unit in accordance with AMCA 500-L.
2. Free Area: 44 percent, nominal.
3. Free Area Size: 6.99 square feet.
4. Maximum Recommended Air Flow through Free Area: 1,361 fpm.
5. Air Flow: 9514 cfm.
6. Maximum Pressure Drop (at 1361 feet per minute): 0.20 inches w.g. (0.05 kPa).

C. Wind Driven Water Penetration Performance:
1. Based on testing 39 inches x 39 inches (1 m x 1 m) core area, 41 inches x 44 inches (1.04 m x 1.12 m) nominal size unit in accordance with AMCA 500-L.
2. Wind Velocity: 29 mph (47 kph).

a. Rainfall Rate: 3 inches/hour (76 mm/hour).
b. Free Area Velocity: 1361 feet per minute (6.9 m/s).
c. Water Resistance Effectiveness: 99.7% (AMCA Class A).

3. Wind Velocity: 50 mph (80 kph).
   a. Rainfall Rate: 8 inches/hour (203 mm/hour).
   b. Free Area Velocity: 778 feet per minute (4.0 m/s).
   c. Water Resistance Effectiveness: 99.0% (AMCA Class A).

D. Design Wind load: Incorporate structural supports required to withstand wind load of 20 pounds per square foot.

E. Louver frame shall be fabricated from 0.081” thick extruded aluminum alloy 6063-T6.

F. Louver blades shall be sight proof, double drainable, fabricated from 0.063” thick extruded aluminum alloy 6063-T6, on centers not exceeding 2”.

G. Birdscreen shall be framed, rear mounted, and removable of ¾” x 0.051” expanded flattened aluminum.

H. Where louvers must be made up by multiple sections, the manufacturer shall submit with the shop drawings, all joint locations, methods of bracing/assembly. When the louvers are assembled per the shop drawings they shall meet the above specified structural loading.

I. Louvers shall have a Kynar 500 finish with a dry film thickness of 1.2 mils. Color to be chosen by the Architect/Engineer from the manufacturer's standard colors, or custom color where scheduled or indicated, at time of shop drawing submittals.
   1. Louver shall have a 5year warranty.
   2. Kynar finish shall have 20 year warranty. Finish coating shall not peel, blister, chip, crack or check. Chalking, fading or erosion of finish when measured by the following tests:
      a. Finish coating shall not chalk in excess of 8 numerical ratings when measured in accordance with ASTM D4214.
      b. Finish coating shall not change color or fade in excess of 5 NBS units as determined by ASTM D2244 and ASTM D822.
      c. Finish coating shall not erode at a rate in excess of 10%/ 5 year as determined by Florida test sample.

J. Louvers shall be Ruskin Model EME520DD, Greenheck Model EHH-501, or approved equivalent by Air Balance Inc., Arrow, or NCA.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install duct accessories in conformance with applicable SMACNA standards.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

D. Volume Damper Installation
   1. Furnish and install volume dampers at each main branch take-off and in such other locations where required to properly balance the air distribution systems.

E. Control Damper Installation
   1. Dampers installed in walls shall be installed with wall sleeves to allow direct coupled actuator installation.
   2. Large damper installations with multiple actuators shall be installed with 8” sheetmetal blank-off/spacers between them to allow direct coupled actuator installation. Provide structural supports as required for a straight, true, level and square installation.
   3. Dampers shall be attached with fasteners on 6” centers with a minimum of 2 per side.
   4. Access panels without window shall be provided at all duct mounted automatic control dampers.

F. Life Safety Damper Installation
   1. Fire, smoke and fire-smoke dampers shall be provided as indicated on the plans and/or schedules. If not scheduled, dampers shall be the full size of the duct they are associated with unless noted otherwise.
   2. Access panels shall be provided at all fire, smoke and fire-smoke damper installations to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   3. Install fire, smoke and fire-smoke dampers in accordance with UL listing.
   4. Diffusers and returns in two (2) hour rated floor/ceiling assemblies shall be equipped with ceiling fire/radiation dampers suitable for this application. Where volume dampers are indicated on the air device schedule along with ceiling radiation dampers, provide a fusible volume adjustment on the radiation damper.

G. Flexible Connector Installation
   1. Furnish and install flexible connections at the connections to air handling equipment as indicated on the plans. The flexible connectors shall be fastened to ductwork and equipment by screws, rivets or spot welding.
   2. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
   3. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

H. Access Door and Panel Installation
   1. Access doors and panels shall be provided as noted herein, upstream of duct mounted reheat coils, multi-zone dampers and as shown on drawings.
   2. Access door and panels shall be installed to swing against the duct static pressure.

I. Intake / Exhaust Louvers, Hoods, Penthouse, Etc.
   1. Furnish and install building air inlets / outlets as sized on the drawings, coordinate opening framing with other trades as required for proper opening size and installation.

2. Install FEMA rated louvers per manufacturer's instructions to maintain FEMA rating.

## 3.2 FIELD QUALITY CONTROL

A. Life Safety Damper Testing
   1. Fire and fire/smoke dampers are to be witness tested by the Owner. The Contractor shall remove the fusible link and demonstrate that the damper closes freely. After acceptance by the Owner, the Contractor shall reset the damper and replace the fusible link.
   2. Inspect life safety damper access to verify the size is adequate to perform the required operation.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.

B. Air Duct Accessory Tests and Inspections
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
   3. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
   4. Operate remote damper operators to verify full range of movement of operator and damper.

C. Flexible Ductwork
   1. Flexible duct length shall not exceed 8' for diffusers.
   2. Support flexible duct on 4' centers maximum.
   3. Flexible duct shall be attached with zinc plated or stainless steel worm drive duct hose clamps.
   4. Install ducts fully extended.
   5. Do not bend ducts across sharp corners.
   6. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
   7. Avoid contact with metal fixtures, water lines, pipes, or conduits.
   8. Install flexible ducts in a direct line, without sags, twists, or turns.

## 3.3 CLEANING AND PROTECTION

A. Clean and protect duct accessories to the same requirements for ductwork.

END OF SECTION 24 30 00

# SECTION 24 33 50 – INTERNAL ACOUSTICAL DUCT LINING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Duct liner.

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Duct liner shall be tested in accordance with test method ASTM C423, Type ‘A’ mounting and have absorption coefficient performance equal to or greater than the table below:

| | Frequency | | | | | |
|---|---|---|---|---|---|---|
| Thickness | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz |
| 1/2" | 0.03 | 0.10 | 0.25 | 0.40 | 0.53 | 0.69 |
| 1" | 0.07 | 0.25 | 0.54 | 0.73 | 0.83 | 0.95 |
| 1-1/2" | 0.17 | 0.39 | 0.72 | 0.88 | 0.95 | 0.95 |
| 2" | 0.24 | 0.53 | 0.83 | 0.95 | 0.95 | 0.95 |

### 2.2 MANUFACTURERS

A. Fibrous glass, Type I:
   1. Johns Manville Linacoustic RC
   2. Johns Manville Spiracoustic Plus (round ductwork).
   3. Knauf Liner M
   4. Owens Corning Aeroflex Plus Type 200
   5. Schuller Permacote Linacoustic Standard

B. Fibrous-glass-free, natural fiber:
   1. Acoustical Surfaces, Inc. - Quietliner™
   2. Bonded Logic
   3. Ductmate PolyArmor

C. Flexible Elastomeric:
   1. Armacell, ArmaFlex, ArmaFlex FS
   2. K-Flex

D. Polyolefin:
   1. Aerofoam AeroSound
   2. Sekisui Thermobreak™ AcoustiPlus

## 2.3 DUCT LINER

A. Acoustical lining shall be a single layer of the thickness scheduled with 90% adhesive coverage applied to the ductwork and the liner applied mat face up.

B. Mechanically welded pins with push on metal heads shall be used on ducts larger than 12” x 12”. Pins shall be copper or shall be as corrosion resistant as the G-90 coated galvanized steel. Spacing around the perimeter shall be 4” from longitudinal liner edges and at intervals not exceeding 12”. Transversely the spacing shall be 3” from transverse joints and at intervals not exceeding 18”.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions.

## 3.2 INSTALLATION

A. Internal duct areas shall be completely covered with duct liner. Each ductwork section shall be covered with a single sheet per side of ductwork, scraps or pieces shall not be used. Longitudinal joints in corners shall be overlapping butt joints. Transverse joints shall be coated with adhesive at the shop prior to shipping the ductwork to the job site and at the time of installation the joints shall be recoated to adhere to one another. Metal nosing and longitudinal joint sealant shall be applied to the first four (4) sections of ductwork at the fan discharge.

B. At all locations of branch fittings, the edges of the main duct liner and the start of branch duct liner shall be sealed with duct liner adhesive.

C. All rips, tears, or other damaged liners shall be repaired by coating the damaged area with liner adhesive. Sections that are not repairable shall be scraped and refabricated.

D. Ductwork with internal lining shall be protected during shipping and at the job site to prevent the liner from getting wet. Ductwork shall not be stood on end or lay directly on the floor of buildings which are not weathertight. In the event that the liner becomes wet it shall be dried in accordance with the manufacturer’s instructions.

## 3.3 CLEANING AND PROTECTION

A. Clean duct lining per the requirements for duct cleaning.

## 3.4 DUCT LINER SCHEDULE

A. Schedule: All supply and return ducts
   1. Supply-Air Ducts:
      a. Type: Fibrous glass, Type I
      b. Thickness: 1-inch
   2. Return-Air Ducts:
      a. Type: Fibrous glass, Type I
      b. Thickness: 1-inch
   3. Exhaust-Air Ducts:
      a. Exhaust ducts will not be internally lined.ductowrk
   4. Supply Fan Plenums:
      a. Type: Fibrous glass, Type I
      b. Thickness: 1-inch
   5. Return- and Exhaust-Fan Plenums:
      a. Type: Fibrous glass, Type I
      b. Thickness: 1-inch
   6. Transfer Ducts:
      a. Type: Fibrous glass, Type I
      b. Thickness: 1-inch

B. All duct liners (except as listed below) shall have a minimum R-valve of 3.8, with a thickness of 1-inch or 1-1/2-inch and a minimum density of 2-lb per ft.3

C. Internal insulation shall be applied to all supply, return, and transfer, rectangular and round ductwork unless otherwise specified.

END OF SECTION 24 33 50

## SECTION 24 34 00 – FANS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Backward-inclined centrifugal fans, including airfoil and curved blade fans.
   2. Centrifugal ventilators - roof down blast.
   3. Square in-line centrifugal fans.
   4. Upblast propeller roof exhaust fans.

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS

1. Provide fans as scheduled on the drawings.
2. Provide accessories as scheduled on the drawings.
3. Provide hangers, supports, isolators, curbs, etc. as necessary for the installation of the fans.

### 2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.3 ROOF EXHAUSTERS

A. Furnish and install where indicated on the drawings centrifugal roof exhaust fans of the sizes and capacities as scheduled. Centrifugal impeller is to be of heavy aluminum construction with backward inclined or curved hollow airfoil blades. Hoods shall be constructed of aluminum with rolled bead for additional strength and shall be easily removable for servicing. Overall height from the curb shall not exceed that of the models scheduled. Motor and drive assembly shall be vibration isolated from the base and housing. All units shall have U.L. wired safety disconnect switch, sound attenuating roof curb and backdraft damper, in addition to any other accessories listed in the schedule.

B. Fans shall be Greenheck G, Cook ACE, Penn-Barry, Domex, ACME PNN, Twin City Fan DCRD, or approved equal.

C. All fans shall have integrated Electronically commutated motors.

## 2.4 IN-LINE CENTRIFUGAL

A. In-line centrifugal fan wheel shall be statically and dynamically balanced aluminum backward inclined blades with deep drawn inlet. Fan housing shall be steel construction with hinged access door. Fan construction shall allow complete servicing without removing the fan from the ductwork.

B. Belt driven fans shall have motor out of the air stream. Direct drive fans will have motor in the air stream.

C. Each fan shall have a wired safety disconnect switch.

D. Fans shall be Greenheck SQ, Greenheck AX, Cook, Penn-Barry, SXBC, ACME XB, Twin City Fan DSI, or approved equal.

# PART 3 - EXECUTION

## 3.1 INSTALLATION, GENERAL

A. Accessories shall be provided as scheduled on the drawings.

B. Install fans level and plumb.

C. Lift equipment with manufacturer’s designated lifting points.

D. Equipment Mounting
1. Secure roof mounted fans to roof curbs.
2. Install floor -mounted centrifugal fans on cast-in-place concrete equipment base(s).
3. Ceiling units shall be suspended from structure; use steel wire or metal straps. Suspend equipment from manufacturer’s designated supporting points.
4. Maintain manufacturer’s recommended service clearance.
5. Equipment shall be labeled in compliance with specifications.

E. Comply with requirements for vibration isolation.

F. Comply with requirements for seismic restraint.

G. Comply with manufacturer’s recommended startup requirements.

## 3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

## 3.3 ROOF EXHAUSTER INSTALLATION

A. Install a vinyl coated steel cable from the motor cover to the base to allow the motor cover to be removed for service, but will not permit the cover to be blown away. Cable shall have eyelet or swagged ends with aluminum or galvanized fasteners.

## 3.4 IN-LINE CENTRIFUGAL FAN INSTALLATION

A. Support fan from spring isolators.

## 3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation where applicable.

B. Adjust belt tension for belt driven fans.

C. Lubricate bearings.

D. Comply with requirements for Testing, Adjusting and Balancing.

## 3.6 FIELD QUALITY CONTROL

A. Perform fan operational test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

B. Test and adjust controls and safeties.

## 3.7 CLEANING AND PROTECTION

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

END OF SECTION 24 34 00

# SECTION 24 36 00 – DUST COLLECTION SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Dust collector.
   2. Dust collection ductwork.
   3. Duct collection accessories.

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 DUST COLLECTOR

A. Dust collector shall be manufactured for indoor installation with a sealed hopper and single (1) 55-gallon drum. Motor and fan shall be enclosed from elements. Shaker and shaker motor shall be enclosed from elements. Dust collector shall be designed for explosion venting. Explosion vent from dust collector shall direct an explosion upward. Filter bags shall be provided with unit. Dust collector shall be Oneida Air System model #XXK100300-220-155 or approved equivalent.

B. Dust collector isolation:

1. Rembe Q-Flap or approved equivalent shall be provided for explosion protection on the inlet side of the dust collector. Inlet flap valve is to be manually armed and held open via magnets.
2. Rembe Q-Rohr or approved equivalent flameless explosion vent shall be provided on the discharge of the collector.
3. A spark detector activated extinguishing system shall be installed on the inlet duct to the dust collector. System shall be Fagus GreCon BS7 or approved equivalent. Coordinate water supply connection requirement to extinguishing system with fire protection contractor.
4. Option – contractor can propose a performance based design in compliance with NFPA 654 and NFPA 664 with substitutions or elimination of various components listed above, contingent on approval by the AHJ.

## 2.3 DUST COLLECTION DUCTWORK

A. Dust Collector Ducting shall consist of the following:
   1. All indoor dust collection ductwork shall be Galvanized: ASTM A653 with a G90 rating. Recommended max. service temperature is 390°F.
   2. All outdoor dust collection ductwork shall be 304SS: Finish meets ASTM A240. Temp rating is 1100°F.

B. Ducting manufacturing techniques:
   1. Diameters 3" - 24" Quick-Fit pipe, adjustable nipples, and collars attached to other components will have one or both ends die formed-rolled to provide a uniform edge around the circumference of the rolled end. The pipe and adjustable nipples shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system. Pipe lengths using laser welded seams will not exceed a nominal 60" length. The rolled edges provide structural support at 5' intervals or less and can be interpreted as a stiffener where SMACNA specifications are required. An adjustable nipple is used for adjustment during the install process. Pipe is cut to appropriate length and the adjustable nipple secures the pipe for install.
   2. Quick-Fit pipe and components larger than 24" shall utilize either an angle flange or flat flange attached loosely and retained in place using a 3/8" Vanstone lip. The flanged pipe shall have a solid welded seam and not exceed nominal 60" length. The angle or flat flanges provide structural support at 5' intervals or less and are considered as stiffeners where SMACNA specifications are required.
   3. Ducting and its components shall be factory tested to +/- 80" WG on pipe diameters 3" to 20" and will use 22 gage material thickness for 3” to 12” duct and 20 gage for larger duct.

C. Clamping rolled edged duct:
   1. Clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.
   2. Approved caulk is 3M Scotch Seal Metal Sealant 2084 or equivalent for system temperatures of 250°F or lower.
   3. Sealing O-rings shall be Buna-N, ASTM D2000 MBC610, 60 Durometer Hardness, with a temperature rating of 250°F maximum and is black in color, used with the adjustable nipple.

4. Sealing gaskets shall be molded and shall meet the material classification of ASTM D-2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 and used in systems where the temperature rating is 225°F or less and are black in color. This component shall be made using conductive materials for conductivity.
5. Sponge O-ring shall meet the material classification of either ASTM D-1056-68 – SBE43 or ASTM D1056-85, 91, 98 – 2B3
6. Clamp seals shall be Nitrile to meet or exceed ASTM D1056 2B2 standards with a temperature rating not to exceed 158°F constant temperature (or intermittent temperature of 194°F).

D. Metal-to-metal contact shall be obtained at all joint connections. Die-formed rolled edges are uniform in shape to provide the most consistent contact. The ears of the clamp contact with the rolled edges and provide maximum conductivity. Conductivity shall be adhered to per NFPA 77 paragraph 8.4.1.1; states all parts of the continuous metal piping system should have a resistance level that does not exceed 10 ohms. Contractor shall field test resistivity.

E. Dust collection ductwork shall be Nordfab Quick-Fit pipe or approved equivalent. Layout shall be factory designed and submit as shop drawing.

## 2.4 DUST COLLECTOR ACCESSORIES

A. Blast Gates: Manual full blast gates shall have aluminum or stainless-steel body and stainless steel or galvanized sliding door with thumb turn lock screw. Blast gate opening shall equal duct size.

B. Floor sweeps: Provide factory manufactured floor sweeps with foot operated lever for opening door.

C. Equipment connections: Provide factory equipment connections for items noted on the drawings. Field verify connection size and specific connection required for each piece of equipment.

END OF SECTION 24 36 00

# SECTION 24 37 00 – AIR DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Air Diffusers
    a. Louvered face ceiling diffusers
    b. Square plaque face diffusers
    c. Linear bar diffusers
    d. Slot diffusers
    e. Architectural continuous linear slot diffusers

  2. Grilles, registers and diffusers
    a. Sidewall return/supply grilles- reversible core
    b. Heavy duty sidewall return grilles

B. Related Requirements:
  1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Submittal data for all distribution devices shall contain the following information:
  1. Room Number
  2. Model Number
  3. Flow Rate
  4. Size: Neck and where applicable
  5. Throw in feet: Based on 50-fpm velocity
  6. Air patterns: Such as one-way, two-way opposite, corner, four-way, etc.
  7. Pressure drop in inches of water
  8. Sound rating
  9. Airflow factor: Such as K factor or as required for airflow rate measurements.
  10. Accessories: Such as volume dampers, deflectors, etc.
  11. Three-color charts

B. Ceiling diffusers shall be of the type, service, size, and finish as scheduled on the drawings. Border types shall be coordinated by the Contractor to be suitable for ceiling types grid width, tile types, drywall, plaster, concealed spline) in which diffusers will be installed.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

B. Balance instructions when special requirements are required.

## 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Devices described herein and indicated on the drawings are based on Titus. Approved equal selections by the following manufacturers will also be acceptable. Such equipment substitutions shall be evaluated on the basis of equivalent performance parameters of throw, pressure drop, and maximum noise criterion (NC). Return or exhaust devices shall not be smaller than sizes shown.
1. AJ Manufacturing Co., Inc.
2. Anemostat
3. Carnes
4. Greenheck
5. Krueger
6. Metalaire
7. Nailor
8. Price
9. Titus
10. Tuttle & Bailey

## 2.3 LOUVERED CEILING DIFFUSERS

A. Material: As scheduled

B. Finish: As scheduled

C. Face Size: As scheduled

D. Construction:
1. An outer frame assembly
2. An integral collar that allows connection to a square or round duct as scheduled
3. An inner core assembly consisting of fixed louvers capable of producing the airflow discharge pattern as indicated on the project plans, and shall be fully removable from the installed diffuser frame for access to any dampers or other ductwork components located in or near the diffuser neck.

E. Mounting:

1. The diffuser shall be supplied with a frame suitable for mounting in the lay-in ceiling system (see architectural).
2. Where installed in a drywall ceiling, a lift-out plaster / drywall frame shall be provided.

F. Accessories:
1. Adjustable pattern deflectors
2. Clips to positively attached lay-in air devices to the ceiling system

G. Basis of design:
1. Supply: Titus TDCA and TDCA-AA
2. Return /Exhaust: Titus TDC and TDC-AA

2.4 SQUARE PLAQUE DIFFUSER

A. Material: As scheduled

B. Finish: As scheduled

C. Face Size: As scheduled

D. Construction:
1. Diffusers shall consist of a seamless, one-piece, precision formed back cone with no corner joints that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
2. The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.
3. An inner plaque assembly shall be incorporated and configured to assure proper air distribution performance.
4. The inner plaque assembly shall be completely removable from the room side to allow for full access to any dampers or other ductwork components located near the diffuser neck.

E. Mounting:
1. The diffuser shall be supplied with a frame suitable for mounting in the lay-in ceiling system (see architectural).
2. Where installed in a drywall ceiling, a lift-out plaster / drywall frame shall be provided.

F. Accessories:
1. Air baffles
2. Clips to positively attached lay-in air devices to the ceiling system
3. Butterfly style flow damper that is room-side adjustable

2.5 SLOT DIFFUSERS

A. Material: As scheduled

B. Plenum: Insulated

C. Finish - Face and Shell: Baked enamel, black

D. Finish - Pattern Controller: Baked enamel, black

E. Finish - Tees: Baked enamel, white

F. Slot Quantity / Width: As scheduled

G. Length: As scheduled

H. Accessories
   1. Plaster frame

I. Basis of Design:
   1. Supply: Titus FTI-10, FTI-15
   2. Return: Titus FL-10, FL-30

## 2.6 SIDEWALL RETURN/SUPPLY GRILLES- REVERSIBLE CORE

A. Material: Aluminum

B. Finish: Baked enamel, color selected by Architect

C. Size: As scheduled

D. Construction:
   1. The grille shall have multiple deflection fixed louver type blades.
   2. Grilles blades and frame shall be extruded aluminum construction.
   3. The grille core shall be field removable from the frame to facilitate inversion or reversing to modify the discharge deflection.
   4. The core shall be held into the frame with steel spring clips.

E. Mounting:
   1. The grille shall be supplied with a 1” flat border mounting frame
   2. The grille shall be configured for Concealed fastening.

F. Accessories:
   1. Directional blades
   2. Steel opposed blade damper

## 2.7 ARCHITECTURAL CONTINUOUS LINEAR SLOT DIFFUSERS

A. Material: Aluminum, 0.062 inches thick.

B. Plenum: Supply: Field fabricated, Insulated; Return: factory return hood/light shield, uninsulated.

C. Finish - Face: Refer to architectural drawings/specifications

D. Finish - Pattern Controller: Refer to architectural drawings/specifications

E. Slot Quantity / Width: As scheduled

F. Length: As scheduled

G. Accessories
   1. Plaster frame, offset frame

H. Basis of Design: Titus Flowbar

## 2.8 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION

A. Air devices shall be installed in the location, orientation and the pattern controllers adjusted as indicated on the plans.

B. Air devices shall be installed in compliance with manufacturers' requirements.

C. Install air diffusers with air-tight connections to ductwork.

## 3.3 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

## 3.4 CLEANING AND PROTECTION

A. Clean air devices at project completion.

END OF SECTION 24 37 00

# SECTION 24 38 10 – TYPE II HOODS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Type II Hoods**.**

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 DEFINITIONS

A. Listed Hood: A hood, factory fabricated and tested for compliance with UL 710 by a testing agency acceptable to authorities having jurisdiction.

B. Standard Hood: A hood, usually field fabricated, that complies with design, construction, and performance criteria of applicable national and local codes.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.4 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Hood
   1. Captive Air
   2. Greenheck

## 2.3 HOOD MATERIALS

A. Material: 430 Stainless Steel

## 2.4 EXHAUST HOOD, TYPE II HOOD (EH-1)

A. Size: 72”L x 48”W x 24”H

B. Mounting Height: 80” off Finished Floor

C. Unit shall be provided with internal lighting option.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions for required clearances and utility connections.

## 3.2 INSTALLATION

A. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, filters/baffles, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.

B. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners unless otherwise indicated.

C. Install hoods to operate free from vibration.

D. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at 48 inches o.c. maximum.

E. Install sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.

F. Install lamps, with maximum recommended wattage, in equipment with integral lighting.

G. Set initial temperatures, and calibrate sensors.

H. Set field-adjustable switches.

## 3.3 CONNECTIONS

A. Where installing piping adjacent to hoods, allow space for service and maintenance.

## 3.4 CLEANING AND PROTECTION

A. Protect hood from damage, duct and debris during storage and installation.

B. Clean hood at project completion.

END OF SECTION 24 38 10

# SECTION 24 41 00 – FILTER ASSEMBLIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Pleated panel filters
   2. V-Bank cell filters
   3. Filter gauges

B. Related Requirements:
   1. Section 24 00 00 Air Distribution

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. ASHRAE Compliance as noted herein.

C. Comply with UL 900

## 2.2 PLEATED PANEL FILTERS

A. 2” and 4” filters shall be dust spot efficiency on ASHRAE Test Standard 52.1 and MERV 8 on ASHRAE Test Standard 52.2. The filter media shall be a self-extinguishing, non-woven cotton and synthetic fabric, UL Class 2. The enclosing frame shall be a rigid, heavy duty, moisture resistant, high wet strength beverage board die cut for dimensional accuracy with diagonal support members. The pleated media pack shall be bonded to the inside of the frame on all four edges to prevent leakage. The media support shall be a welded wire grid bonded to the filter media to reduce media oscillation. The media support shall be contoured shape allowing total use of the filter media for longer life.

1. 2” filters shall not have less than 14 pleats per linear foot and not less than 17 square feet of effective media (based on 24” x 24”). Filters shall be as manufactured by Camfil-Farr Filter model 30/30, American Air Filter model 300X, or approved equivalent.
2. 4” filters shall not have less than 21 pleats per linear foot and not less than 27 square feet of effective media (based on 24” x 24”). Filters shall be as manufactured by Camfil-Farr Filter model 30/30, American Air Filter model 300X, or approved equivalent.

## 2.3 V-BANK CELL FILTERS

A. Second stage filters shall be high-efficiency pleat-in-pleat V-bank disposable type. Filter media shall be microfine glass formed into uniformly spaced pleats separated by fiberglass thread separators and formed into a minipleat pack design. Each minipleat pack shall be assembled into a V-bank configuration. Filter shall be rated as UL Class 2.

1. 12” deep 65% dust spot efficiency on ASHRAE Test Standard 52.1 and MERV 11 on ASHRAE Test Standard 52.2. Filters shall have not less than 200 square feet of effective media based on 24” x 24” size. Filters shall be as manufactured by Camfil-Farr Filter model Durafil ES, American Air Filter model VariCel VXL, or approved equivalent.
2. 12” deep 95% dust spot efficiency on ASHRAE Test Standard 52.1 and MERV 14 on ASHRAE Test Standard 52.2. Filters shall have not less than 200 square feet of effective media based on 24” x 24”. Filters shall be as manufactured by Camfil-Farr model Durafil ES, American Air Filter model VariCel VXL, or approved equivalent.

## 2.4 SIDE-ACCESS FILTER HOUSINGS

A. Housing shall be a complete factory assembled housing with upstream and downstream outwardly turned flanges for insertion into the ductwork system. The housing shall be manufactured of a minimum of 16 ga. reinforced galvanized steel. Access doors with continuous gasketing on the perimeter shall be provided at both ends of the housing. When an access door is opened, the filter cartridges shall be slid into the housing where they shall be retained on slide channels. These channels shall incorporate a positive-sealing gasket material to seal the top and bottom of the filter cartridge frames to prevent bypass. Leakage shall be prevented between cartridges, and between cartridges and doors, by factory installed gasketing. Positive-latching handles will seal the access doors to the housing. Filter cartridges shall be capable of being loaded or unloaded through either access door.

B. Housings for 4” filters shall be 12” housing depth as manufactured by Camfil-Farr Filter model 4P Glide/Pack, Flanders/Air Seal model FL4, American Air Filter model Polyseal, or approved equivalent.

## 2.5 FILTER GAUGES

A. Each filter assembly shall have a gauge arranged to measure pressure across each filter type in housings containing more than one filter. Provide all necessary pressure taps, tubing, fittings, valves, and mounting hardware. Gauges shall be Dwyer Model 2001 or equivalent (0-1" range for single stage 30% filters) (0-2" range for 65% or greater filters or multiple stages). Each filter assembly shall have an engraved plastic plate indicating what the final change-out pressure is for each type of filter.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Filters shall be installed before running any equipment (temporary or permanent).

B. Inspect equipment to ensure that cleaning has been completed before filters are installed.

## 3.2 INSTALLATION

A. For duct mounted filter housings assemblies provide access doors upstream and downstream of the duct filters.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Filters shall be replaced prior to balancing.

E. Install filter gauge for each filter bank.

F. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

## 3.3 CLEANING AND PROTECTION

A. Final filters shall not be installed until units, filter housings, and ductwork have undergone a filter cleaning process to remove construction debris.

**END OF SECTION 24 41 00**

# TABLE OF CONTENTS

## DIVISION 25 – TEMPERATURE CONTROL SYSTEM

# SECTION 25 00 00 – TEMPERATURE CONTROL SYSTEM

## 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. Provisions and conditions cited in this Section shall apply to Work for other sections of Divisions 25 of these Specifications.
   1. Section 25 10 00 – Control System Requirements
   2. Section 25 20 00 – Airside Control Equipment
   3. Section 25 30 00 – Hydronic Control Equipment
   4. Section 25 40 00 – Auxiliary Equipment
   5. Section 25 50 00 – Wiring Materials and Methods

C. The following sections of the Specifications apply to Work under this Section
   1. Division 20 - Basic Mechanical, Plumbing and Fire Protection
   2. Division 22 – Plumbing work
   3. Division 23 – HVAC Piping and Equipment
   4. Division 24 – Air Distribution
   5. Division 26 – Electrical
   6. Division 27 – Communications

### 1.2 SUMMARY

A. This Section specifies an Automation/Energy Management System to control and monitor HVAC systems.

### 1.3 REFERENCES

A. Applicable requirements of the current and accepted edition of the following industry standards, codes and specifications shall apply to the Work for Division 25
   1. ASHRAE 36 – High-Performance Sequences of Operation for HVAC Systems
   2. ASHRAE Standard 135-2016, BACnet – A Data Communication Protocol for Building Automation and Control Networks.
   3. BACnet Testing Laboratories (BTL) for product testing and certification.
   4. FCC rules, Part 15, Subpart J, regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
   5. NFPA 70 – National Electrical Code
   6. UL 864

Underwriters Laboratories Standard for Standard for Control Units and Accessories for Fire Alarm Systems

7. UL 916 Underwriters Laboratories Standard for Energy Management Equipment.

## 1.4 DEFINITIONS

A. Adjustable (Adj.): Where used in this Section of the Specifications shall be defined as values that are adjustable at the GUI without the need for any software. This adjustment may be password protected to limit access to an appropriate user level and may use an adjustment mechanism similar to point overrides.

B. Control Loop or Loop: Used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the guidelines in the following subsections shall be followed.

C. Control Wiring: All wiring, 120 VAC line voltage or lower other than power wiring, required for the proper operation of the mechanical system and the BAS. This includes applications where line voltage serves as the control circuit such as a line voltage thermostat or involves interlocking with a damper.

D. Deadband: The difference between two setpoint or configuration values during which no output function is performed.

E. Dewpoint Temperature or Dewpoint: The saturation temperature of water in moist air, as evidenced by the temperature at which water will condense out of air. Dewpoint temperature is an evaluation of the absolute water content of moist air, so for control applications, it is used where moisture content of air needs to be maintained, such as humidification or dehumidification processes.

F. Differential: The range or units of measure that separate the enable point from the disable point.

G. DDC or Direct Digital Control: A control technique through which the process variable is continuously monitored by a digital computer which accomplishes loop control by calculating a control solution for output to a control device.

H. Discharge Temperature: The temperature discharged from a piece of equipment, but not necessarily to an end use consumer.

I. EMS Energy Management System, BAS Building Automation System: May be used interchangeably in this Section of the Specifications to mean a system to control mechanical equipment using DDC. This definition includes both hardware and software components that are integrated to form a working system.

J. Enthalpy: The psychrometric quantity equivalent to the total heat content of air. It is usually used to evaluate if the outside air contains less heat than the return air and determine whether to enable economizer.

K. Hard Wired Control: A control method using relays to enable and interrupt signals without the use of a controller.

L. Proportional: A set of signals that vary in a continuously linear relationship with each other. They may be direct or reverse acting.

M. Power Wiring: All line voltage wiring to the mechanical and BAS equipment that is required for proper operation of the equipment. Typically, this wiring will support voltage at or above 120 VAC and is connected to the equipment for the purpose of providing motive power.

N. Proven (i.e., "proven ON"/"proven OFF"): The equipment's DI status point (where provided, e.g., current switch, DP switch, or VFD status) matches the state set by the equipment's DO command point.

O. Relative Humidity: The psychrometric property that is an evaluation of how much water vapor is present in air relative to the capacity of air at the current temperature and pressure to hold water. While it is a good measure of comfort levels, the temperature dependence of this value can make it an unstable control variable.

P. Software Point: An analog variable, and "software switch" shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

Q. Supply Temperature: The temperature supplied to an occupied zone or terminal equipment point of use.

R. Temperature: The psychrometric value dry bulb temperature.

S. Wet Bulb Temperature: The psychrometric property wet bulb temperature is the equilibrium temperature at which liquid water evaporates into the air at saturation. It can be measured with a thermometer that has a wick saturated in water. For control processes, it is typically used for the control of cooling towers since it is related to the evaporation of water in air. This is a different value from dewpoint temperature.

T. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

U. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

V. BACnet Specific Definitions:
   1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
   2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
   3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
   4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

W. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

X. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.

Y. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

Z. COV: Changes of value.

AA. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

BB. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.

CC. E/P: Voltage to pneumatic.

DD. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

EE. HLC: Heavy load conditions.

FF. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

GG. I/P: Current to pneumatic.

HH. LAN: Local area network.

II. LNS: LonWorks Network Services.

JJ. LON Specific Definitions:
1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.

6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

KK. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

LL. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

MM. Modbus TCP/IP: An open protocol for exchange of process data.

NN. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

OO. MTBF: Mean time between failures.

PP. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

QQ. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

RR. Peer to Peer: Networking architecture that treats all network stations as equal partners.

SS. POT: Portable operator's terminal.

TT. RAM: Random access memory.

UU. RF: Radio frequency.

VV. Router: Device connecting two or more networks at network layer.

WW. Server: Computer used to maintain system configuration, historical and programming database.

XX. TCP/IP: Transport control protocol/Internet protocol.

YY. UPS: Uninterruptible power supply.

ZZ. USB: Universal Serial Bus.

AAA. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

BBB. VAV: Variable air volume.

CCC. WLED: White light emitting diode.

## 1.5 QUALITY ASSURANCE

A. Work for this Section of the Specifications shall be performed in accordance with the Codes, Standards, etc. as identified in Division 20.

B. All operable devices and features of the BAS, accessories, equipment and specialties provided for in the Scope of Work of this Section shall be operated and proved to function satisfactorily for a period of number (x) days. Adjust, balance, lubricate as required, and instruct the Owner in the proper operation and maintenance of each device.

C. Equipment and devices shall be protected against damage in the period between installation and acceptance. Any item damaged shall be removed, repaired and/or replaced at no additional compensation.

## 1.6 ACTION SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 25.

## 1.7 INFORMATIONAL SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 25.

1.8 CLOSEOUT SUBMITTALS

A. Refer to Division 1, Division 20, and each section of Division 25.

B. As-built drawings of electrical circuit numbers, power panels, remote sensors, outdoor air sensor building differential pressure sensor and reference probes.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 25 00 00

# SECTION 25 10 00 – CONTROL SYSTEM REQUIREMENTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Automation/Energy Management System to control and monitor HVAC systems.

B. Related Requirements:
   1. Section 25 00 00 TEMPERATURE CONTROL SYSTEM

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of product 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.
   4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Coordination Drawings: Control panel locations, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer’s installation manual: For each type of product.

B. Field quality-control reports.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Johnson Controls

B. ENTERPRISE SERVER HARDWARE

C. An application server on the Owner's enterprise IT infrastructure will be used to host the Enterprise Server application for the project. The Owner will create a virtual machine on one of their existing servers, and this contractor will be granted remote access permissions to install and administer the Enterprise Server application for this contract.

D. Web server or workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the DDC System manufacturers minimum requirements for their software. Provide sufficient internal memory for the specified sequences of operation and trend logging. The contractor is responsible for supplying all hardware, software, configuration, maintenance, including security for the application server.

## 2.3 ENTERPRISE SERVER SOFTWARE

A. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
   1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
   2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
   3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.

4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

B. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.
1. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Manual Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
3. System Configuration: The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
4. On-Line Help: Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security: Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.
a. Operator Access: The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location of the equipment, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.
b. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
c. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
d. System Diagnostics: The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.

C. The Enterprise Server shall contain licensing required for all system hardware and software needed to fulfill the requirements of the plans and specifications. This includes, but is not limited to: Point counts, connected controllers, RS-485 network drivers, TCIP/IP network drivers, third party integration protocols.

D. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

E. Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.

F. Alarm Reactions: Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

G. Alarm and Event log: Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.

H. Trend Logs: The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Trends shall be BACnet trend objects.

I. Object and Property Status and Control: Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.

J. Clock Synchronization: Provide open-protocol time synchronization service for all controllers on the connected network. The system shall automatically synchronize system clocks daily via the distributed network. The system shall automatically adjust for daylight savings and standard time as applicable.

K. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

L. Standard Reports: Furnish the following standard system reports:
   1. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
   2. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
   3. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:
      a. Alarm History.
      b. Trend Data: Operator shall be able to select trends to be logged.
      c. Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

M. Workstation Application Editors: Each browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.
   1. Controller: Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.

2. Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
3. Custom Application Programming: Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
   a. Language: Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
   b. A full-screen character editor programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate features such as cut/ paste and find.
   c. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.
   d. The programming language shall support conditional statements (IF/THEN/ELSE/ ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
   e. The programming language shall support floating-point arithmetic using the following operators: +, , ÷, ×, and square root. The following mathematical functions also shall be provided: absolute value and minimum/maximum value.
   f. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program.
   g. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.

## 2.4 BUILDING CONTROLLERS (BC)

A. Building Controllers (BC) shall be capable of being networked on a peer to peer network with other Building Controllers as well as being networked to a campus Ethernet LAN as standard or through an additional communication module. The supporting firmware and hardware shall be configured and arranged so that a dedicated LAN is not required for networking of the system controllers. In other words, the system shall be capable of interfacing with an existing Ethernet LAN which is on line and handling communications between other data systems, and using this LAN for handling its own inter controller communications without interference from or interference to the original communications occurring on the network. Having only a proprietary communications bus available at this level will be unacceptable. The files and data transferred on the network may be proprietary and use proprietary file and data string structures. The minimum communication rate shall be 100 Mbps.

B. Building Controllers shall function as communications/network controllers supporting both communications to other Building Controllers on a high level, high speed bus as well as communications to Custom Application Controllers (CAC) and Application Specific Controllers

(ASC) on lower level Local Area Networks (LANs). The following specific functions shall be required.

1. Provide an adequate number of BC to achieve the performance specified in "BAS PERFORMANCE."
2. The BC shall have sufficient memory to support its operating system, database, and programming requirements.
3. Controllers that perform scheduling shall have a real-time clock.
4. Support for a high level communications using Ethernet, or other high-speed protocol. The files and data transferred on the network may be proprietary and use proprietary file and data string structures. The minimum communication rate shall be 100 Mbps. High level communications will reside on Tier 2 communications.
5. Support for a low-level communications bus or busses for communications between lower level controllers such as Custom Application Controllers, Application Specific Controllers, and Third Party Devices. Low level communications will be Tier 3 communications.
   a. Custom Application Controllers are stand-alone controllers that are fully custom programmable.
   b. Application Specific Controllers are small, low point density, low memory stand-alone controllers with pre-programmed sequences geared to a very specific application lacking in the ability to do custom control sequences but providing "fill in the blank" programming simplicity. Controllers are suitable for use in controlling terminal equipment such as reheat coils, constant volume regulators, variable volume boxes, fan coil units, fan terminal units, etc.
   c. Third Party Devices include Variable Frequency Drives, Chillers, Boiler Control Panels, Lighting Control Systems, and other devices included in the specifications that share information with the DDC system. At the contractor's option, Third Party Devices may be isolated by a BACnet MS/TP router. In that instance, the router and all configuration shall be provided by this contractor.
   d. The low level communications bus shall be BACnet MS/TP utilizing TIA-485. Minimum communications speed shall be 19,200 baud. Low level communications bus networks utilizing LonWorks, Modbus, or proprietary protocols shall be clearly identified in the submittal process and are subject to review and acceptance.
6. Each Building Controller shall perform the following energy management routines as a minimum:
   a. Event based programming
   b. Time of day programming
   c. Optimized time of day programming
   d. Demand control
   e. Duty Cycling
   f. Global data sharing (one point used by multiple controllers)
   g. Programmable schedule over rides
   h. Scheduling
   i. Hours of operation accumulation
   j. Reporting
   k. Trending
   l. Alarming
   m. Time synchronization of controllers
   n. Customized start-up on power failure
7. Each Building Controller shall perform customized control strategies based upon arithmetic, Boolean or time delay logic. The arithmetic functions shall permit simple relationships between variables as well more complex relationships (i.e., square root,

exponential). The system shall permit the generation of job specific control strategies that can be activated in any of the following ways:

a. Continuously
b. At a particular time of day
c. On a pre defined date
d. When a specific measured or controlled variable reads a selected value or state
e. When a piece of equipment has run for a certain period of time

8. Upon a loss of commercial power to any Building Controller, the other units within the network shall not be affected, and the loss of operation of that unit shall be reported at the designated operator's terminal. All control strategies and energy management routines defined for the BC shall be retained during a power failure with the unit. Upon resumption of commercial power, the control unit shall resume full operation without operator intervention including updating all monitored functions, resume operation based on synchronized time and status, and custom start-up strategies.
    a. Each Building Controller shall contain an uninterruptible hardware real time clock accurate to ten (10) minutes per year. The clock shall contain the time of day, day, month, year, and day of the week. The system shall automatically correct for daylight savings time and leap years.
9. The BC shall contain self-diagnostics that continuously monitor the proper operation of the unit. A malfunction of the unit will be reported, and will inform the operator of the nature of the malfunction, and the control unit affected. It shall be possible to annunciate malfunctions as well as other control unit alarms at a selected central operator's terminal.
10. Building Controllers shall be sized to meet the requirements of the number of distributed and networked Custom Application Controllers, Application Specific Controllers, and Third Party Devices. Those requirements shall include, but not be limited to, the number of devices, the complexity of control sequences, the number of global points, the number of trends (and size of trends considering number of samples required), the number alarms, and the physical distances between subordinate networked nodes.

## 2.5 CUSTOM APPLICATION CONTROLLERS

A. General

1. Each Custom Application Controller (CAC) shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each unit shall be a microprocessor-based, multi-tasking, real-time digital control processor. Custom Application Controllers shall be fully programmable controllers capable of supporting and executing user defined programs in addition to firmware-based routines. Programming in the modules shall function independently of the Building Controller and shall not depend on a functional communications network for execution. Loss of communications with other Custom Application Controllers, or Building Controller, shall result in the programming either continuing to execute in its most recent state or returning to some user defined default routine based on the detection of the communications failure by the Custom Application Controllers firmware or software. The ability to detect and respond to a communications failure will be required.
2. Custom Application Controllers shall be native Tier 3 communication devices.
3. Custom Application Controllers shall be applied to Air Handling Units as well as system level control (Chilled Water System, Condenser Water System, Hot Water System, for example).

4. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its Building Controller is lost and to ensure protection during power outages.
5. Provide each unit with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM or a minimum of 72-hour battery backup shall be provided. All programs shall be field-customized to meet the user's exact control strategy requirements. Controllers utilizing pre-packaged or canned programs are not acceptable.
6. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.
7. Each controller shall have connection provisions for a portable laptop PC. It shall allow the user to display, generate or modify all point databases and operating programs.
8. The unit shall be capable of direct interface to a variety of industry standard sensors and input devices. It shall be possible for each unit to monitor the following types of inputs:
   a. Analog inputs: 4 20 mA, 0 10 VDC, Thermistors, RTDs.
   b. Digital inputs: Dry contact closure, Pulse accumulator.
9. The unit shall directly control electronic actuators and control devices. Each unit shall be capable of providing the following control outputs:
   a. Analog outputs: 4 20 mA, 0 10 VDC.
   b. Digital outputs: Dry contact closure (pilot duty).
10. Each CAC within the building control system shall perform control functions as defined by the operator. All control functions shall be executed within the CAC unit. Loop control shall be executed via direct digital control algorithms.

B. It shall be possible to fully create, modify or remove control algorithms within a specific CAC unit while it is operating and performing other control functions. Changes shall be made either through a direct connection of the CAC and a laptop PC or via the network with a laptop PC connected to another controller or via the network from the Operator Workstation.

## 2.6 APPLICATION SPECIFIC CONTROLLERS

A. Each Application Specific Controller (ASC) shall operate as a standalone controller capable of performing its control responsibilities independent of controllers in the network. Each unit shall be microprocessor based, digital control processor.

B. Application Specific Controllers shall be applied to unitary equipment like Packaged Rooftop Air Handling Units (if controls not provided with RTU), Fan Coil Units, Unitary Ventilation Units, Variable Air Volume Terminal Units, etc.

C. Application Specific Controllers shall be native Tier 3 communication devices.

D. Each ASC shall either have a battery backed-up real time clock or shall receive a synchronized time and occupied/unoccupied status from a supervisory controller. Upon restoration after a loss of power, the ASC shall revert to its previous state prior to loss of power, or scheduled status based upon the value of the real time clock.

E. All programs and user-defined configurations shall be stored in non-volatile EEPROM or have a minimum of 72-hour battery backup.

F. Each terminal unit shall be individually controlled using an ASC controller. ASC controllers shall communicate with the Building Controller via Tier 3 communication to implement global control strategies including occupied/unoccupied, space setup/setback, warm-up/cooldown. Each ASC controller or the thermostat shall have access to allow local configuration at the terminal unit. ASC controller shall be mounted in the terminal unit control cabinet or as shown on the drawings.

1. ASC for use with VAV or fan powered terminals (FTU) shall have a differential pressure transducer based flow sensor. Standard control routines shall include pressure independent VAV, constant volume, parallel FTU, series FTU, and dual duct as required by the sequences of operation. The control routines shall include: shutdown mode, power fail restart mode, occupied/unoccupied mode, temporary occupied mode, warm-up mode, setpoint calculation, temperature control loops, damper control, fan control, exhaust box control, baseboard heat, box heat, lighting control, and auto zero.
2. ASC for use with fan coil units, heat pumps, unit ventilators, small packaged rooftop, or generic point multiplexer shall include the following control routines: shutdown mode, power fail restart mode, occupied/unoccupied mode, temporary occupied mode, warm-up mode plus those required by the sequence of operations for the type of equipment being controller.
3. Where ASC controllers are to be installed on terminal units, such as VAV boxes, reheat boxes, fan coil units, etc., the units may be field or factory installed or field installed. Regardless of whether the units are factory or field installed, all responsibilities and costs associated with coordinating this installation shall be carried by and under this section of the specification. This includes, but is not limited to, actuator coordination, velocity sensor coordination, relays, auxiliary contacts, enclosure requirements, power requirements, failure mode, normal position upon loss of power and signal, etc.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. All devices relating to the work or systems included herein, including controllers, valves, motors, relays, auxiliary panels, etc., shall be identified with a unique identification number or name on the submitted engineering drawings. This identification number or name, along with the service of the device (discharge air controller, mixed air controller, etc.), shall be permanently affixed adjacent to the respective device. Identification shall be vinyl labels printed with thermal transfer printers, ½” high labels minimum.

C. Terminal strips shall be labeled using plastic labels designed to snap into the label mounting slots on the terminals. For input/output wiring, cabling, or tubing, the panel side of the terminals shall be labeled with the automation panel circuit board and terminal numbers associated with the point.

D. All wiring, tubing, and cabling both inside and outside of control panels shall be labeled at both ends using Thomas and Betts EDP printable wire and cable markers using style WSL self laminating vinyl. Input and output cables and wiring shall be labeled with the point number and the point description.

E. Cable and wiring not specifically associated with an input or output shall be labeled with a number and a function description.

## 3.3 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver control devices to unit manufacturer for factory installation. Include installation instructions to unit manufacturer.

## 3.4 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

C. Graphical User Interface
   1. The Graphical User Interface (GUI) computer shall be a network computer provided and maintained by the Owner on their Local Area Network. Interface to the BAS GUI shall be through a web browser installed on that computer (Safari, Microsoft Edge, or Chrome), native and compatible with the Operating System installed on that computer.
   2. Basic Interface Description
      a. GUI shall be English language prompting, English language point identification, on-line help, and industry standard PC application software. The software shall provide, as a minimum, the following functionality:
         1) Real-time graphical viewing and control of environment.
         2) Scheduling and override of building operations.
         3) Collection and analysis of historical data.
         4) Definition and construction of dynamic color graphic displays.
         5) Editing, programming, storage and downloading of controller databases.
         6) Alarm reporting, routing, messaging, and acknowledgment.
         7) Display of dynamic trend data plot.
      b. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows:
         1) Dynamic color graphics and graphic control.

2) Alarm management, routing to designated locations, and customized messages.
3) Week at a Glance Time-of-day scheduling.
4) Trend data definition and presentation.
5) Graphic definition and construction.
6) Program and point database editing on-line.

c. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation that they log onto.

d. Operator Activity Tracking - An audit trail report to track system changes, accounting for operator initiated actions, changes made by a particular person or changes made to a specific piece of equipment over a designated time frame shall be printable and archived for future use. The operator activity tracking shall be in a tamperproof buffer file.

e. Reports shall be generated on demand or via pre-defined schedule and directed to either displays, printers, email recipient, or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
1) A general listing of all or selected points in the network.
2) List of all points currently in alarm.
3) List of all points currently in override status.
4) List of all disabled points.
5) List of user accounts and access levels.
6) List all weekly schedules.
7) List of holiday programming.
8) System diagnostic reports including a list of DDC panels on line and communicating and status of all DDC terminal unit device points.
9) List of programs.

f. Scheduling and override shall be accomplished via a graphical format for simplification of time-of-day scheduling and overrides of building operations.

g. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Archival trend data may be stored at the Enterprise Server for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
1) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily exported in CSV format.

3. Dynamic Color Graphic Displays

a. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

b. Dynamic values, with the specified units and precision, for temperature, humidity, flow, position, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without predefined screen refresh rates.

c. Provide the user the ability to display blocks of point data by defined point groups.

d. Alarm conditions shall be identified graphically unique from other monitor points, with the use of flashing, text color, text background color, or other indication native to the DDC software platform.
e. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.
f. Colors shall be used to indicate status and change as the status of the equipment changes.
g. A dynamic display of the site specific control architecture showing the status of all controllers, operator workstations, and networks shall be provided.

4. System Configuration & Definition
   a. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
   b. Provide automatic backup and restore of all DDC controller databases on the Enterprise Server. In addition, all database changes shall be performed while the workstation is online without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
   c. System configuration, programming, editing, graphics generation shall be performed online.
5. Alarm Management
   a. Alarm Routing shall allow the user to send alarm notification to network printers or email recipients based on time of day, alarm severity, or point type.
   b. Alarm Notification shall be provided priority levels, to distinguish between routine, maintenance type alarms and critical alarms.
      1) There shall be 4 levels of alarm
         a) Level 1: Life-safety message
         b) Level 2: Critical equipment message
         c) Level 3: Urgent message
         d) Level 4: Normal message
   c. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message.
   d. Alarm messages shall be customized to each point to display detailed instructions to the user regarding actions to take in the event of an alarm.
   e. Maintenance Mode: Operators shall have the ability to put any device (e.g., AHU) in/out of maintenance mode.
      1) All alarms associated with a device in maintenance mode will be suppressed. Exception: Life safety alarms shall not be suppressed.
      2) If a device is in maintenance mode, issue a daily Level 3 alarm at a scheduled time indicating that the device is still in maintenance mode.
   f. Entry Delays: All alarms shall have an adjustable delay time such that the alarm is not triggered unless the alarm condition is TRUE for the delay time. Default entry delays are as follows:
      1) Level 1 alarms: 1 seconds
      2) Level 2 alarms: 10 seconds
      3) Level 3 alarms: 1 minutes
      4) Level 4 alarms: 5 minutes

g. Exit Hysteresis: Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
   1) Each analog alarm shall have an adjustable percent-of-limit-based hysteresis (default: 0% of the alarm threshold, i.e., no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.

h. Latching: Any alarm can be configured as latching or non-latching. A latching alarm requires acknowledgement from the operators before it can return to normal, even if the exit deadband has been met. A non-latching alarm does not require acknowledgment. Default latching status is as follows:
   1) Level 1 alarms: latching
   2) Level 2 alarms: latching
   3) Level 3 alarms: non-latching
   4) Level 4 alarms: non-latching

i. Post-exit Suppression Period: To limit alarms, any alarm may have an adjustable suppression period such that, if the alarm is triggered, its post-suppression timer is triggered and the alarm may not trigger again until the post-suppression timer has expired. Default suppression periods are as follows:
   1) Level 1 alarms: 0 minutes
   2) Level 2 alarms: 5 minutes
   3) Level 3 alarms: 24 hours
   4) Level 4 alarms: 7 days

j. For both latching and non-latching alarms, the operators may acknowledge the alarm. Acknowledging an alarm clears the alarm, the exit deadband, and suppression period. A device can go right back into alarm as soon as the entry delay elapses.

6. Workstation Communications - Provide remote access for buildings as required by the contract documents. Automatic dial-out communications shall include the following features as a minimum:
   a. Critical alarms shall automatically dial out for email recipients to be defined in the software database.
   b. Alarms shall automatically display at the Graphical User Interface.

7. Application Notes for Specific Graphic Displays
   a. System schematics for each piece of mechanical equipment, including air handling units, chilled water systems, hot water boiler systems, and zone controls shall be provided to optimize system performance analysis and speed alarm recognition. System arrangement on the graphical displays shall match the installed equipment configuration exactly, with respect to order and arrangement of components.
   b. Each graphic shall contain the date, time, outdoor air temperature and humidity.
   c. Floor plan graphics shall display zone temperatures. A graphic component indicating the actual location of the zone temperature sensor shall be included for each terminal unit or unitary equipment. Where a single VAV box is controlling multiple spaces, it should clearly identify all zones served by that VAV box.
   d. System summary screens in a tabular format shall be provided for each system for overall system operation evaluation by the operators. These screens do not have graphical representation of the equipment, but are dynamically populated spreadsheet-type presentations of operational data of the supplied systems.
      1) Each individual air handling unit shall have a summary of the terminal units it serves, with one terminal unit on each row of the table. The table columns

shall be: the terminal unit tag, zone temperature setpoint, zone temperature, airflow setpoint, airflow, damper command/position, heating command, discharge air temperature.

2) An air system summary shall be provided, with one air handling unit on each row of the table. The table columns shall be: equipment tag, discharge temperature setpoint, discharge temperature, static pressures, fan status, fan speed command, cooling command, heating command, damper commands.

e. Cooling Plant Graphics: Graphics showing cooling towers shall include outdoor air wet bulb temperature. When applicable, cooling plant graphics shall show number of pressure reset requests.

f. Air Handling System Graphics: When applicable, system graphics shall show number of incoming heating and cooling requests, pressure reset requests, total VAV flow, total VAV flow setpoint, Max VAV damper position, and Min VAV damper position.

g. VAV Graphics: All VAV graphics shall include room name and number, and a link to the RTU which serves the VAV.

D. Implementation/Development of Sequences of Operation

1. Software sequences shall be provided as described on the drawings and/or as specified herein and as required to initialize and load the field point data base.
2. These sequences are intended to be performance based. Implementations that provide the same functional result using different underlying detailed logic will be acceptable.
3. Software testing requirements shall include testing in the field of all logic sequences including actual simulation of different processes and events and observing program response to the process or event. All deviations from the requirements of the sequence as specified shall be corrected immediately at no additional cost to the Owner.
4. Where several analog outputs are to be controlled in sequence by one control loop, software shall be arranged so that the sequence is guaranteed regardless of the spring range of the actuators and to prevent simultaneous heating and cooling.
5. Programs controlling several pieces of equipment as one system shall reside in one field panel. Where programs use data points that reside in other panels the programs shall employ logic (either in software, firmware, hardware, or a combination of all three) to detect loss of communications with the remote panels containing the required data. When such a failure is detected, the program logic shall revert to a safe operating mode that will allow the controlled systems to remain in operation until normal system communication resumes.
6. Network dependent processes should be avoided. For control processes, particularly control loops, all input sensor readings, output device operations, and logic control algorithms shall reside in a single field controller. For particularly difficult applications, or for less critical applications, network dependent processes should be presented specifically to the Engineer during the Shop Drawing submittal for review and acceptance.
7. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup.
8. When a control loop is enabled or reenabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value.
9. A control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.
10. Outside air conditions

a. When there are multiple outdoor air temperature sensors, the system shall use the valid sensor that most accurately represents the outdoor air conditions at the equipment being controlled.

b. Outdoor air temperature sensors at air-handler outdoor air intakes shall be considered valid only when the supply fan is proven ON and the unit is in occupied mode or in any other mode with the economizer enabled.
c. The outdoor air temperature used for optimum start, plant lockout, and other global sequences shall be the average of all valid sensor readings. If there are four or more valid outdoor air temperature sensors, discard the highest and lowest temperature readings.

11. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.). Do not use the derivative term on any loops unless field tuning is not possible without it.
12. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.
13. All set points, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.
14. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point, and the software point shall be used in all sequences. Exceptions shall be made for machine or life safety.
15. Every sensor input data point shall incorporate input value filtering, a time averaged value is preferable to change of value (COV) techniques. Due to the great variety in filtering requirements based on sensed value stability and process variable use, a prescriptive specification will not be provided in this guideline requirement. Rather, this requirement is to ensure that filtering is present in some form so that it may be adjusted during system tuning and acceptance, if so required, at no additional programming or cost.
16. VFD Speed Points
    a. The speed AO sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz, and 100% speed corresponds to maximum speed configured in the VFD.
    b. Minimum and maximum speeds shall be configured in the VFDs such that the controlled device cannot operate outside of its design range when operating in Auto or Hand.
    c. The controller shall not send an AO signal which is below the minimum allowed % speed of the device.
17. Provide all required standard data base development, input, and debugging as required by the project and point list including but not limited to point names, point groupings, point ranging, point alarm limits, backup file creation, message development, graphics development, etc.
    a. Equipment controller naming, hardware naming, software naming, etc. shall all be named to match the unique equipment tag listed on the equipment schedules.
        1) For terminal devices and unitary equipment, the area of service description shall be the actual room number(s) on the building signage plus the space description agreed upon with the Owner.
    b. Effort has been made to identify equipment on the equipment schedules in a manner consistent with the Owner’s naming conventions. In the course of execution of this work, if equipment tags are found to be inconsistent with known standards, this contractor will bring these inconsistencies to the attention of the engineer for adjustments required.

18. The point lists indicated on the points list and sequences of operation are minimum requirements for the job. The contractor shall provide all input and output points required by his system to perform the indicated sequence of operation, regardless of whether or not they are specifically listed in the points list or sequence of operation.
    a. All set points shall be developed as software points stored at memory locations so that set points can be changed by recommending the data stored at the memory location rather than by entering the program and changing parameters and lines in programs.

E. Database Semantic Tagging

1. The purpose of a data modeling standard is to provide a consistent, standardized methodology for naming and describing data points associated with facility automation systems, equipment systems, energy metering systems, other smart devices including mobile assets, and associated descriptive information known as metadata.
2. This project will implement the Project Haystack database semantic tagging model.
3. Technical Overview
    a. The Project Haystack data modeling standard for Buildings and Equipment systems uses a simple metamodel based on the broadly accepted concept of "tags" as described below. Tags are <u>not</u> point names in the Temperature Control System. They are independent entities that do not specifically describe the point or equipment in an of itself, but entities that specifically describe the point or equipment when they are queried as a group.
    b. Tags are name/value pairs, associated with entities like AHUs, electric meters, etc. Tags support the definition of the following essential data elements:
        1) Entity: An Entity is an abstraction for a physical object in the real world. Entities include sites, facilities, equipment, sensor points, weather stations, etc.
        2) Id: The id tag is used to model the unique identifier of an entity in a system using a Ref value type. Ref value types are determined by individual application. This identifier may be used by other entities to cross-reference entities, associations, and systems.
        3) Dis: The dis tag is used with entities to define display text used to describe an entity. Dis values are intended to be short (less than 30 or 40 characters), but fully descriptive of the entity for a human user.
    c. The model provides the following permitted tag value types:
        1) Marker: this tag type is merely a marker annotation with no meaningful value. Marker tags are used to indicate a "type" or "is-a" relationship.
        2) Bool: boolean "true" or "false".
        3) Number: integer or floating point number annotated with a Unit of Measurement, where ideally, units of measure are prescribed for various tasks.
        4) Str: a string of Unicode characters.

5) Uni: a Universal Resource Identifier.

6) Ref: reference to another entity. The Project Haystack specification does not currently prescribe specific identities or reference mechanisms, but should be used to cross link entities. Refs are formatted with a leading "@" and require a specific subset of ASCII characters be used: a-z, A-Z, 0-9, underbar, colon, dash, or dot.

7) Bin: a binary blob with a MIME type formatted as Bin(text/plain)

8) Date: an ISO 8601 date as year, month, day: 2011-06-07.

9) Time: an ISO 8601 time as hour, minute, seconds: 09:51:27.354.

10) DateTime: an ISO 8601 timestamp followed by timezone name: 2011-06-07T09:51:27-04:00 Chicago, 2012-09-29T14:56:18.277Z UTC

4. The Project Haystack data modeling standard provides a comprehensive library of standard tags to address common equipment, building systems, and devices types. Tags shall be developed and implemented in accordance with this standard library.

5. Application

a. The goal of the Project Haystack data modeling standard is to ensure consistent modeling of building systems, devices and associated data. The following application requirements outline the use of the modeling standard in applications related to buildings, energy, and facility management.

b. The Haystack Project implementation shall utilize defined data modeling tags to create an expanding, and coherent model with the following minimum items, hierarchy and relationships when used in facilities-oriented applications:

1) Sites: Including display name, description, size (area) as a minimum. References to Internet-available weather stations are highly recommended, as are creating tags to represent other relevant characteristics of a Site such as year constructed, facility usage type, occupancy class, schedule(s) of operation, building systems type (e.g., packaged or central HVAC).

2) Equipment: Including standardized associations with sites via id reference and display name as a minimum. Equipment and software vendors, model numbers, year of installation, and similar descriptive meta data are also recommended.

3) Points: Including standardized associations with sites and equipment via id reference, units of measure as a minimum. Where possible, ranges of acceptable values are recommended.

c. Exposing the Project Haystack Model via REST API: Software and web service applications, including control system devices will expose the model definitions described above using the Project Haystack REST API published as part of the Project Haystack standard, openly accessible and kept up to date at http://project-haystack.org/doc/Rest.

d. Open Source Modules for Commercially Available Products.

1) The Project Haystack Community has developed, and makes available, a comprehensive implementation of the Haystack protocol in the form of a software module for use with NiagaraAX-based systems. The module, known as NHaystack, is licensed under the Academic Free License ("AFL") v. 3.0.

Public access to the NHaystack software module shall be maintained via the project-haystack.org site.

2) When Niagara 4-based systems are used, the arcbeam.jar module shall be the installed in the Enterprise Server and each Station to provide communication between the Niagara 4-based devices and SkySpark systems that are interacting with Niagara data or writing commands to Niagara 4-based systems.

F. Calibration Requirements

1. Calibration shall be checked at a minimum of one point on the span of the device for temperature, pressure, and humidity sensors.
2. Specified accuracy shall be achieved at the field termination points of the device and shall include both sensor errors and transmitter errors.
3. For flow meters provide a factory calibration certificate where manufacturing tolerance are verified to prove geometric similarity to the original design standard upon which the product accuracy statements are based. NIST certificates are not required unless specifically noted in the flow meter specification.

G. System Performance Standards

1. System shall conform to the following minimum standards over network connections:
   a. Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 s.
   b. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 s.
   c. Object Command: Devices shall react to command of a binary object within 2 s. Devices shall begin reacting to a command of an analog object within 2 s.
   d. Object Scan: Data used or displayed at a controller or workstation shall have been current within the previous 6 s.
   e. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 45 s. Note that this is not a statement of alarm state evaluation, only of announcement of the alarm condition.
   f. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 s. Select execution times consistent with the mechanical process under control.
   g. Performance: Programmable controllers shall be able to completely execute BAS PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.

H. Auxiliary Panels Installation and Fabrication

1. Auxiliary panels shall be fabricated to match the approved shop drawings submitted by the control contractor. Fabrication shall be in a neat and workmanlike manner and shall facilitate repair, maintenance, and adjustment of the equipment contained therein.
2. All equipment that is not providing an input from a field sensed process (static pressure, temperature, proof of flow, etc.) shall be installed in an auxiliary panel located as indicated on the drawings or as directed by the engineer.
3. Auxiliary panels shall be fabricated and laid out to incorporate the following features:
   a. Identification of all internally and cover mounted devices. Cover mounted labels shall be engraved labels or shall be vinyl labels printed with thermal transfer printers, 1” high labels minimum. Labels for internal devices may be shall be vinyl labels

printed with thermal transfer printers, ½” high labels minimum. Labels shall be mounted adjacent to the device they are associated with so that replacement of the device does not eliminate the label.

b. All input and output wiring entering the stand alone control units shall be terminated on terminal strips. If such terminal strips are not furnished as a standard part of the stand-alone control unit termination points, then they shall be installed in an auxiliary panel located immediately adjacent to the stand-alone unit.

c. All internal wiring shall be run inside plastic wiring duct as manufactured by Tyton. Wire duct shall be sized to hold the required number of wires without crimping the wires and with sufficient space to allow wiring to be traced during troubleshooting operation.

d. Wires that pass from the panel interior to cover mounted devices shall be provided with a flex loop that is anchored on both sides of the hinge.

e. All panels shall be provided with removable sub-panels to allow the panel enclosures to be installed at the job site during rough in while the panels are fabricated off site for later installation.

f. Provide strain relief type cord and cable connectors for all cables that leave the panel as individual cables not in conduit.

g. Provide one duplex outlet mounted inside the control panel and separately fused with a non time delay fuse at 15 A at any panel location containing electronic or electrical control components. This receptacle may be served from the control panel’s 120 VAC power source.

h. Each panel shall be provided with a control power disconnect switch located and wired so as to disconnect all control power in the panel. The leaving side of this switch shall be wired to the panel and field components through a fuse or fuses sized and applied to protect both the components of the system as well as the wire and as required for code compliance.

i. Enclosures shall be NEMA 1 for indoor dry locations and NEMA 4/12 for indoor wet and outdoor locations. Enclosures shall be fabricated from a minimum of 16 gauge steel with continuously welded and ground smooth seems. Doors shall have hinges to open 180°, oil resistant gasket, a removable print pocket, quarter turn latch mechanism with key lock handle and lock cylinder. Grounding studs shall be welded to both the body and the door. Collar studs shall be provided to mount a subpanel. Finish shall be gray ANSI 61 polyester powder inside and out over phosphatized surfaces.

j. All wiring leaving the panel shall be separated by classification; i.e., Class 1 circuits shall not be run with Class 2 circuits, etc. Segregation shall be maintained inside the panel to the fullest extent possible. Where low voltage wires carrying low level AC and DC signals cross wires containing power and high level ac signals, the wires shall cross at a 90° angle.

k. Panels shall be shop fabricated and tested prior to installation in the field. The Owner's representative shall be given the opportunity to witness the testing of the panels. The panels may be inspected and approved by the Owner's representative at the assembly location prior to installation in the field.

l. Panels with controls for equipment and systems that operate on generator power shall have a local UPS power supply integral to the primary power circuit of the panel to retain controller power throughout the Automatic Transfer Switch switching period, minimum of 10 s.

## 3.5 TRAINING

A. The contractor shall provide a representative from the company used as the source for the electronic controllers used in the systems installed under this contract. The representative shall conduct the training class on the project site at a time scheduled in advance with the Owner and shall occur during or immediately following system start up. These instructions are to be conducted during normal working hours. All pertinent costs shall be included in this contract.

END OF SECTION 25 10 00

# SECTION 25 20 00 – AIR SIDE CONTROL EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Air temperature sensors
   2. Humidity sensors
   3. Differential pressure sensors
   4. Automatic control dampers and actuators
   5. Airflow measurement

B. Related Requirements:
   1. Section 25 00 00 TEMPERATURE CONTROL SYSTEM

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 OUTDOOR AIR TEMPERATURE SENSOR

A. Sensor shall be tip sensitive 10,000 ohm Thermistor or 1,000 ohm RTD.
   1. Thermistor element shall be 10,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

2. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

B. The housing shall be a NEMA 4 aluminum box with gasket cover or ABS enclosure that will accept water tight conduit connections. The sensor shall be integrally shielded from sunlight and weather with good ventilation for accurate readings, do not rely on building structure to provide shade. If sensor is not provided with integral sun shield, provide optional accessory to accommodate.

C. Precon model ST-O, ACI model A/xx-O-BB(EH), BAPI model BA/10K(1K)-O-BB2, or approved equivalent.

## 2.3 DUCT TEMPERATURE SENSOR – FOR AIR HANDLING UNIT SYSTEMS

A. Sensor shall be tip sensitive 10,000 ohm Thermistor or 1,000 ohm RTD.
1. Thermistor element shall be 10,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.
2. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

B. The housing shall be a 4” x 2” galvanized steel utility box with cover or ABS enclosure that will accept conduit connections. The bottom of the housing shall have a foam gasket to seal the housing to the duct to minimize air leakage.

C. Minco model S451PFY, Precon model ST-Dx-XH(P), ACI model A/10K(1K)-D-8-GD(BB), BAPI model BA/10K(1K)-D-8”-JB, or approved equivalent.

## 2.4 DUCT TEMPERATURE SENSOR – FOR TERMINAL UNIT EQUIPMENT

A. Sensor shall be tip sensitive 10,000 ohm Thermistor or 1,000 ohm RTD.
1. Thermistor element shall be 10,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.
2. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

B. The sensor shall be provided without enclosure, but with mounting tabs, grommet seal, and integral plenum rated cable of sufficient length (5’ minimum) that sensor terminations are made directly at the terminal unit controller without any splices between sensor and controller.

C. Precon model KTVx-XCP5, Mamac model TE-701-BX-x-A, BAPI model BA/10K(1K)-D-4”-NB-5’, or approved equivalent.

## 2.5 DUCT TEMPERATURE BENDABLE AVERAGING ELEMENTS

A. Sensor shall be bendable copper or aluminum sheath, continuous sensing 10,000 ohm Thermistor or 1,000 ohm RTD.
1. The element shall be 10,000 ohm thermistor, with a reference temperature coefficient of resistance (TCR R25/125) compatible with the system installed, ±0.36°F accuracy.

2. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

B. The housing shall be 4” x 2” galvanized steel utility box with cover or ABS enclosure that will accept conduit connections. The bottom of the housing shall have a foam gasket to seal the housing to the duct to minimize air leakage.

C. Sensor length shall provide coverage of 20’ element per 25 square feet of installed area.

D. Precon model ST-FZ, ACI Model A/xx-A-24-GD, BAPI model BA/10K-x-A24-JB, or approved equivalent.

## 2.6 LOW LIMIT THERMOSTAT (FREEZESTAT)

A. Low limit thermostats shall be snap-acting contact thermostats with vapor-charged sensing element. Thermostat shall have normally closed SPST main contact and normally open SPST auxiliary contact. Main contact shall be rated 16 A inductive load at 120 VAC. Auxiliary contact shall be rated 16 A inductive load at 120 VAC.

B. Thermostat shall have setpoint range of 15°F – 55°F.

C. Thermostat shall have a 20-foot long remote bulb strung in free air downstream of the heating coil but upstream of the cooling coil. The control shall respond to the lowest temperature along any one foot section of sensing element.

D. The coil shall have the manufacturer’s recommended coverage, with 20’ element per 25 square feet of installed area minimum. Provide multiple thermostats wired in series where the coil area exceeds the maximum coverage.

E. Low limit thermostat reset.
1. Manual reset low limit thermostats shall be operate by manual reset (no fixed differential).
2. Automatic reset low limit thermostats shall operate on a fixed 5°F differential.

F. Manual reset low limit thermostats shall be Johnson Controls A70HA-1C, Robertshaw T322, or approved equivalent.

G. Automatic reset low limit thermostats shall be Johnson Controls A70GA-1 or approved equivalent.

## 2.7 ROOM TEMPERATURE SENSOR

A. Room temperature sensors listed in this section shall be for auxiliary sensing applications only, as indicated on the Drawings, Sequences of Operation, or Points Lists. Room temperature sensors applied to terminal unit controllers are specified under Room Smart Sensors.

B. Sensor shall be tip sensitive 10,000 ohm Thermistor or 1,000 ohm RTD.
1. Thermistor element shall be 10,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.
2. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

C. Sensor covers.
   1. Sensor with plastic covers shall match the Room Smart Sensors on the project.
   2. Flush sensors shall be box-mounted flush stainless steel wall plate.

## 2.8 ROOM SMART SENSOR

A. Room smart sensors shall be integral components of the DDC system ASC controller line. They should be the sensors that are generally applied for terminal unit zone controls. They are sensors that are generally available in a variety of configurations that have temperature sensing as a base function but include options for additional sensors and configurations for project-specific requirements.
   1. Sensor chassis shall be configured to provide aspiration of all sensing elements for accurate indication of zone condition when installed on a wall surface.
   2. Temperature Sensor: Temperature sensor shall be integral to the board assembly of the device, shall have a sensing range of 32°F-104°F, with an accuracy of 0.35°F.
   3. Temperature Indication: Local indication of temperature shall display the same value that is in use by the control routine resident in the associated ASC. Local displayed values that differ from the controlling program are not permitted. Temperature indication shall be whole number values only (no decimals displayed) or rounded to nearest 0.5°F if a single decimal place is enabled.
   4. Insulated bases are required for all Room Smart Sensors installed on exterior walls or on furred-out columns.
   5. Temperature Setpoint Adjustment: Temperature setpoint adjustment mechanisms are preferred to be provided with relative adjustment indication (higher/lower, blue/red, left/right) rather than absolute values printed on the device (specific temperatures).
   6. Occupancy Override: A local push-button shall be provided on the Room Smart Sensor for manual initiation of temporary occupancy override.
   7. Relative Humidity Sensor: Relative humidity sensor shall be integral to the board assembly of the device, shall have a sensing range of 20%RH-80%RH (non-condensing), with an accuracy of ±2%RH.
   8. Carbon Dioxide Sensor: Carbon dioxide sensor shall be integral to the board assembly of the device, shall have a sensing range of 400 ppm-1250 ppm, with an accuracy of ±40 ppm and ±3%.
   9. All sensors shall have service jack for local configuration.
   10. The sensor options included herein are common for sensors of this type. The values to be monitored are specific to this project. As the options available in a single sensor vary by manufacturer, if the required options for a specific zone are not available in a single device for the installed system, it is the responsibility of this contractor to provide the number of devices (and full installation including rough-in, wiring, devices, programming, and engineering) to comply with the requirements of the zone.

B. Sensor configuration will vary by zone requirements. Configuration types are listed below:
   1. Type S1 shall have Temperature Sensor only.
   2. Type T1 shall have Temperature Sensor and Temperature Setpoint Adjustment only.
   3. Type T2 shall be similar to Type T1, with addition of Occupancy Override.

4. Type T3 shall be similar to Type T2, with addition of Temperature Indication.
5. Type TH1 shall have Temperature Sensor, Relative Humidity Sensor, and Temperature Setpoint Adjustment only.
6. Type TH2 shall be similar to Type TH1, with addition of Occupancy Override.
7. Type TH3 shall be similar to Type TH2, with addition of Temperature Indication.
8. Type TC1 shall have Temperature Sensor, Carbon Dioxide Sensor, and Temperature Setpoint Adjustment only.
9. Type TC2 shall be similar to Type TC1, with addition of Occupancy Override.
10. Type TC3 shall be similar to Type TC2, with addition of Temperature Indication.

## 2.9 GENERAL PURPOSE RELATIVE HUMIDITY SENSOR

A. Due to the wide variation in Relative Humidity sensor performance and the importance of the information used based on their readings, the sensors listed herein as approved sensors have third party testing results verifying performance characteristics. A primary resource for this reference is the National Building Controls Information Program April 2004 Product Testing Report on Duct-Mounted Relative Humidity Transmitters. The intent of the listed products is not to limit manufacturers used, but to ensure similar demonstrated performance of allowed devices. Consideration for substitute sensors should include a similar published third party product report. Consideration for substitute sensors will be made based on Owner’s current installed stock. Application consideration has been given to differentiate use of the sensors specified herein above and beyond the use of Room Smart Sensors specified elsewhere in this specification. Engineer has determined that the sensors indicated in this section are required for this specific application.

B. General Purpose Duct Relative Humidity Sensor:
   1. Sensor shall employ bulk polymer resistance or capacitance technology, 3% RH accuracy, 4-20 mA or 0-5 VDC transmitter factory matched and calibrated and replaceable tip. Sensor may incorporate integral temperature sensor. Sensor shall be ACI A/RH3-D or approved equal.

C. General Purpose Room Relative Humidity Sensor:
   1. Sensor shall employ bulk polymer resistance or capacitance technology, 3% RH accuracy, 4-20 mA or 0-5 VDC sensor transmitter factory matched and calibrated and replaceable tip.. Sensor may incorporate internal temperature sensor. Sensor shall be ACI A/RH3-R, JCI HT-6703-0N00W, Mamac HU-225-3 or approved equal.

D. General Purpose Outside Relative Humidity Sensor:
   1. Sensor shall employ bulk polymer resistance or capacitance technology, 3% RH accuracy, 4-20 mA or 0-5 VDC transmitter factory matched and calibrated and replaceable tip. Sensor may incorporate integral temperature sensor. If not included in base model, provide

sun shield. Sensor shall be ACI A/RH3-O or approved equal (including substitution provisions indicated above for this specific product).

## 2.10 HIGH LIMIT HUMIDISTAT

A. Humidistat shall be duct-mounted (or internal unit-mounted with a bracket) as indicated on the drawings. Sensor shall have a nylon ribbon sensing element, 15% to 95% RH setpoint dial and a nylon ribbon sensing element, 15% to 95% RH setpoint dial and a snap-acting SPDT switch.

B. Humidistat shall change state when sensed humidity is above setpoint (5% RH differential). The contacts shall be rated for 8 A resistive load at 120 VAC. The normally closed contacts shall be wired to the humidifier valve safety circuit as indicated on the drawings and sequence of operation.

C. The humidistat shall automatically reset when sensed humidity is below setpoint (5% RH differential).

D. Humidistat shall be Schneider Electric model HC-201 or approved equal.

## 2.11 GENERAL PURPOSE AIR DIFFERENTIAL PRESSURE TRANSMITTER

A. Transmitter range shall be as indicated on the Points List. Transmitter shall be a fixed range device, <u>multi-range devices are not acceptable</u>.

B. Transmitters shall be a two-wire device producing a 4-20 mA output. Accuracy shall be 1% full scale or better, including non-linearity and hysteresis.

C. Transmitters that are panel mounted may be open frame design. Transmitters that are not installed in an auxiliary control panel shall be provided with an enclosure that accommodates a conduit connection.

D. Transmitter shall be Setra model 264, Ashcroft model CXLdp, or Modus model T30.

## 2.12 VERY LOW AIR DIFFERENTIAL PRESSURE TRANSMITTER

A. Transmitter range shall be as indicated on the Points List. Transmitter shall be a fixed range device, <u>multi-range devices are not acceptable</u>.

B. Transmitters shall be a two-wire device producing a 4-20 mA output. Accuracy shall be 0.5% full scale or better, including non-linearity and hysteresis.

C. Transmitters shall be panel mounted, with be open frame design.

D. Transmitter shall be Setra model 269, Ashcroft model CXLdp, or Ashrcoft model XLdp.

## 2.13 DIFFERENTIAL PRESSURE TRANSMITTER SENSING PROBE

A. For unit or duct mounted pressure sensing locations, provide static pressure probe with ¼" brass barb or compression connection and gasketed mounting flange. Static pressure probe shall be Mamac model A-520, Dwyer model A-489/491/493, or approved equal.

B. For space mounted pressure sensing locations, provide flush mounted white ABS static pressure probe with ¼" barb connection, for mounting on single gang electrical box or ceiling tiles. Static pressure probe shall be Mamac model A-523, Dwyer model A-465, or approved equal.

C. For outside air reference pressure sensing locations, provide plastic pressure probe with internal reservoir, sensing head baffle to negate wind effects, mounting bracket, and 50 feet of vinyl tubing. Device shall be Dwyer A-420A/A-306/A-306-A or approved equal.

## 2.14 CARBON DIOXIDE (CO2) SENSORS

A. Due to the wide variation in Carbon Dioxide sensor performance and the importance of the information used based on their readings, the sensors listed herein as approved sensors have third party testing results verifying performance characteristics. A primary resource for this reference is the National Building Controls Information Program June 2009 Product Testing Report on Wall-Mounted Carbon Dioxide Transmitters. The intent of the listed products is not to limit manufacturers used, but to ensure similar demonstrated performance of allowed devices. Consideration for substitute sensors should include a similar published third party product report. Consideration for substitute sensors will be made based on Owner's current installed stock. Application consideration has been given to differentiate use of the sensors specified herein above and beyond the use of Room Smart Sensors specified elsewhere in this specification. Engineer has determined that the sensors indicated in this section are required for this specific application.

B. Sensor shall employ beam absorption infrared sensing technology with detection range of 0 – 2,000 ppm and an accuracy of 3%. Sensor shall be in a white enclosure for mounting directly within room without readout display and appear similar to room temperature sensor. Output to be 4-20 mA transmitter factory matched and calibrated.

C. Room sensor shall be ACI Model A/CO2-VEN, Honeywell Vulcain Model SM90DM3A, Telaire Ventostat T8100, or approved equal (including substitution provisions indicated above for this specific product).

D. Duct sensor shall be ACI Model A/CO2-Duct, Honeywell Vulcain Model SM90DM3A, Telaire Ventostat T8041, or approved equal (including substitution provisions indicated above for this specific product).

## 2.15 AUTOMATIC CONTROL DAMPERS

A. Control dampers shall be provided where indicated on the drawings or as required for proper system operation.

B. Airfoil Control Dampers
   1. Dampers shall be constructed from minimum 12 gauge extruded aluminum blades and frames. Blades shall be locked to the blade shaft by a positive means other than setscrews. Such means include ribs extruded into the blade that fit slots in the damper shaft and hexagonal shafts that fit tightly in hexagonal holes extruded into the blades.
   2. Shafts shall be provided with bearings at all support locations.
   3. Dampers shall be equipped with blade and jamb seals and shall have a leakage rate less than 0.1% of maximum flow.
   4. Linkage shall be concealed in the jamb out of the air stream where such an arrangement will be accessible for maintenance and lubrication without removal of the unit from the duct system or fan system that it is installed in. In all other cases the linkage shall not be concealed in the frame.
   5. Dampers with vertically oriented blades shall be provided with thrust bearings to support the vertical blades.
   6. Airfoil dampers shall be provided where fan discharge dampers are required and/or where minimum pressure drop at full flow is necessary.
   7. Dampers shall be Ruskin Model CD-40, Greenheck Model VCD-43 or approved equal.

C. General Purpose Control Dampers
   1. General purpose control dampers shall be constructed from minimum 16-gauge steel or minimum 12 gauge extruded aluminum blades and frames. Blades shall be locked to the blade shaft by a positive means other than setscrews. Such means include ribs extruded into the blade that fit slots in the damper shaft and hexagonal shafts that fit tightly in hexagonal holes extruded into the blades.
   2. Shafts shall be provided with bearings at all support locations.
   3. Dampers shall be equipped with blade and jamb seals and shall meet the leakage specifications indicated on the damper schedule.
   4. Linkage shall be concealed in the jamb out of the air stream where such an arrangement will be accessible for maintenance and lubrication without removal of the unit from the duct system or fan system that it is installed in. In all other cases the linkage shall not be concealed in the frame.
   5. Dampers with vertically oriented blades shall be provided with thrust bearings to support the vertical blades.
   6. Non Airfoil dampers shall be provided at locations where Airfoil dampers are not required. Dampers shall be sized to provide adequate pressure drop at full flow to insure adequate control without hunting.
   7. Dampers shall be Ruskin CD-36, Greenheck Model VCD-23 or approved equal.

D. Control Damper Sizing and Application
   1. Modulating damper sizing shall be based on the following conditions:
      a. Minimum velocity - 2000 fpm
      b. Maximum velocity - 3000 fpm
      c. Minimum pressure drop - 0.2”w.c.
      d. Maximum pressure drop - 0.3”w.c.

e. Coordinate with the installing trade contractor any required blank-off plates for dampers that are smaller than duct size.

2. Two position dampers shall be the full size of the duct they are associated with unless otherwise specified.
3. Flow rates for damper sizing shall be based upon the flow rates indicated on the equipment schedules.

## 2.16 DAMPER ACTUATORS

A. Actuators shall be sized with enough torque to close damper against fan shut off pressure. Provide multiple dampers and actuators as required to obtain close off. In all cases torque shall be a minimum 7.5 in-lb/ft2 for opposed blade dampers and 10.5 in-lb/ft2 for parallel blade dampers.

B. Actuators shall be direct coupled electric actuators with electronic overload or digital rotation sensing circuit to prevent damage to the actuator throughout the full range of movement. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.

C. For power-failure/safety applications, a mechanical spring return mechanism shall be used. Non-mechanical forms such as battery back-up and capacitor discharge are not acceptable. The normal position is the position that the actuator must fail to upon loss of control signal or power.

D. Proportional and triac actuators shall have an external gear release. Spring return proportional actuators shall have a manual crank to allow manual positioning when the actuator is not powered.

E. Proportional actuators shall accept a 2 to 10 VDC or 4-20 mA input signal. Actuators shall operate on less than 10 VA.

F. Actuators shall have a direction rotation switch to aid in installation and provide proper control response.

G. Actuators shall be listed under UL873.

H. Actuators shall have a 2-year warranty starting from the date of acceptance.

I. Actuators shall be Belimo, Siemens, or approved equal.

J. Unless noted elsewhere, the following shall apply for damper actuator application:
   1. Air handling unit control dampers shall be 2-10 VDC proportional, spring return actuators. Outdoor air and relief air shall be NC, return air shall be NO.
   2. VAV box damper actuators shall be Triac (tri-state).
   3. Smoke dampers shall be 2-position, spring return NC, and shall have 120 VAC actuators.

K. Actuators installed on the exterior of the building shall be provided with a NEMA 4X protective housing accessory as manufactured by the actuator manufacturer, Belimo ZS-300 or approved equal. Field-assembled steel weather shields or polycarbonate weather shields are not acceptable.

## 2.17 THERMAL DISPERSION AIRFLOW MEASUREMENT

A. Thermal dispersion airflow sensors shall be used in duct-mounted applications only, with air filters at some location upstream of the airflow sensor.

B. Thermal dispersion airflow sensors shall have an assembly installed airflow accuracy of ±3% of reading for duct and plenum applications.
   1. Probes shall be rated for -20°F to 140°F, 0% RH to 100% RH (non-condensing) ambient conditions.
   2. Transmitters shall be rated for -20°F to 120°F, 5% RH to 90% RH (non-condensing) ambient conditions.
   3. Transmitter shall be provided with two field selectable, scalable and isolated analog output signals. One output shall be for airflow indication, the other output shall be selectable temperature or alarm.
   4. Airflow measurement probe shall have ±2% of reading accuracy and shall be calibrated to a range of 0 fpm – 5,000 fpm over 16 calibration points.
   5. Temperature measurement probe shall have ±0.15°F accuracy and shall be calibrated to a range of -20°F to 160°F over 3 calibration points.

C. Flow meter shall be Ebtron Advantage 3 Gold Series, Ruskin Model TDP05K, Air Monitor ELECTRA-flo or approved equal.

## 2.18 VORTEX SHEDDING AIRFLOW MEASUREMENT

A. Vortex shedding airflow sensors shall be used in duct-mounted applications. Air filters at some location upstream of the airflow sensor is preferred, but is not required.

B. Vortex shedding airflow sensors shall have an assembly installed airflow accuracy of ±3% of reading for duct and plenum applications.
   1. Probes shall be rated for -20°F to 140°F, 0% RH to 100% RH (non-condensing) ambient conditions.
   2. Transmitters shall be rated for -20°F to 120°F, 5% RH to 90% RH (non-condensing) ambient conditions.
   3. Transmitter shall be provided with field selectable, scalable and isolated analog output signal for airflow indication.
   4. Airflow measurement probe shall have ±2% of reading accuracy and shall be calibrated to a range of 0 fpm – 5,000 fpm over 16 calibration points.

C. Flow meter shall be Accutrol VorTek G3 VTD Series, or approved equal.

## 2.19 FIXED ORIFICE DIFFERENTIAL PRESSURE AIRFLOW MEASUREMENT

A. Differential pressure across a fixed orifice shall be utilized for outdoor intake airflow measurement applications.

B. Differential pressure across fixed orifice airflow sensor probes shall be 316 Stainless Steel and shall be constructed so they are not affected by moisture, dirt, or debris.
   1. Fixed orifice shall be expanded steel in galvanized steel flanged casing.
   2. Flow transmitter shall be in a NEMA 1 enclosure, with integral graphic display and keypad for field configuration, stacked transducers for each channel, barometric pressure compensation, ambient temperature compensation, and four configurable outputs for the DDC system.

C. Flow meter assembly shall be the appropriate mounting adaptation of the OAM II System from Air Monitor Corporation.

## 2.20 ENGINEERED OUTDOOR AIRFLOW MEASUREMENT SYSTEM

A. Engineered outdoor air airflow measurement systems shall be utilized for outside airflow measurement at air handling units with mixing box configurations.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions.

## 3.2 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the products specified in this section and related accessories to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

## 3.3 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

C. Outdoor Air Temperature Sensor
   1. Outdoor air sensor shall be located where shown on the drawings or in a place as directed by the Architect/Engineer. Location shall be accessible for annual routine maintenance of sensor for calibration or replacement.

D. Duct Temperature Sensor – For Air Handling Unit Systems
   1. Sensor length shall be coordinated with ductwork; length shall be at least 6” beyond insulation or inner wall of duct.

E. Duct Temperature Sensor – For Terminal Unit Equipment
   1. Sensor length shall be coordinated with ductwork; length shall be at least 4” beyond insulation or inner wall of duct.
   2. Sensor shall be installed on a vertical duct face, at the midpoint of the duct to avoid stratification and mixing effects from the reheat coil. Sensors shall not be installed on the top or bottom of the duct without explicit direction or approval of the Engineer. Sensor

shall be installed before the first air outlet tap from the distribution ductwork, but as far downstream as allowable by the integrated plenum cable.

F. Duct Temperature Bendable Averaging Elements
1. Temperature sensing elements shall be strung in free air and shall not be supported from the face of the coil to prevent the temperature of the coil media from affecting the element reading.
2. Where element is bent to turn in air stream, provide a manufactured insulated capillary mounting clip at each turn point. Capillary mounting clip shall be Klipet CC-1G-K, M-648-K copper clad mounting clip (only if element insulated from metal-to-metal contact with polyethylene tubing around element within capillary clip), or approved equivalent.

G. Low Limit Thermostat (Freezestat)
1. All low limit thermostat circuits shall have a manual reset function to restore normal system operation following correction of freeze condition. The manual reset function may be achieved with manual reset low limit thermostats, or with automatic reset low limit thermostats and manual reset circuits as indicated below:
   a. For installations where all low limit thermostats can be mounted on the exterior of the unit, or inside the unit on the same side as the access door, and within 8 feet of the finished floor, manual reset low limit thermostats may be used.
   b. For installations where any low limit thermostat is mounted above 8 feet over the finished floor or on the interior of the unit on the opposite side of the access door, automatic reset low limit thermostats with manual reset circuits must be used.
   c. Application of automatic reset low limit thermostats requires the pairing of a manual reset circuit. That manual reset circuit may be achieved with a latching relay and pushbutton reset, or with a packaged fan safety relay board with manual reset switch, at contractor’s option. The reset button may be located at the unit in a remote enclosure, or inside the unit control enclosure, at contractor’s option.
   d. Low limit thermostat arrangements must meet the installation details indicated in the specifications that follow, and must meet the manufacturer’s installation requirements.
2. Temperature sensing elements shall be strung in free air and shall not be supported from the face of the coil to prevent the temperature of the coil media from affecting the element reading. Where element is bent to turn in air stream, provide a manufactured insulated capillary mounting clip at each turn point. Capillary mounting clip shall be Klipet CC-1G-K, M-648-K copper clad mounting clip (only if element insulated from metal-to-metal contact with polyethylene tubing around element within capillary clip), or approved equivalent.
3. The thermostat shall only be installed in the vertical position, with the sensing bellows on the bottom of the thermostat. The thermostat shall be mounted above the capillary sensing tube and the sensing tube shall run horizontally, below the bellows.

H. Room Mounted Device Installation:
1. All devices shall be installed on boxes or mounting plates secured to the building structure, wall studs, etc., prior to the installation of the wall covering or finish.
2. Rough ins for low voltage electric and/or electronic devices shall consist of a box or plate with the required number of conductors or cables securely fastened to it and extended to a location out of the wall in which the thermostat is mounted for connection to the control system. Conduit shall be provided at locations where the conductors will be embedded in plaster, concrete, or masonry to protect the conductors and allow easy replacement if necessary.

3. Rough ins for line voltage devices shall be in conduit in all cases.
4. Mounting heights for temperature sensors, thermostats, or relative humidity located on walls in occupied spaces shall be adjacent to the light switch (for ADA accessibility) unless otherwise directed by the Architect/Engineer.
5. Mounting heights for CO2 and other gasses with a density similar to air, or other sensors not requiring user adjustment, located on walls in occupied spaces shall be at 60" AFF, unless otherwise directed by the Architect/Engineer.
6. Mounting heights of sensors for gasses lighter than air (methane, ammonia, etc.) shall be located near or on the ceiling, gasses heavier than air (refrigerants, propane, etc.) shall be located near the floor, review proposed locations with Engineer prior to installation.
7. All room sensors installed on exterior walls shall include insulated backing, utilizing 0.25" closed cell foam pads as a minimum.

I. Room Temperature Sensor
1. Temperature sensors installed in occupied spaces shall have plastic covers that match the Room Smart Sensors on the project.
2. Temperature sensors installed in common areas (corridors) or secure areas shall be box mounted with flush stainless steel wall plate.

J. Room Smart Sensor
1. Unless noted differently elsewhere, S1 shall be used in public spaces (i.e., corridors, restrooms, lounges, etc.), T2 shall be used in Offices, TC2 for Conference Rooms, T1 shall be used in all other spaces.
2. Unless explicitly specified or approved by the Engineer, all Room Smart Sensors shall be wired devices connected to the terminal equipment they control, wireless sensors are not allowed without explicit instruction or approval prior to bid submittal.

K. General Purpose Air Differential Pressure Transmitter
1. If not designated otherwise on the Points List, sensor ranges shall be as follows:
   a. AHU downstream (remote from unit) duct static pressure transmitters shall be unidirectional, 0-2.5"w.c. range.
   b. AHU discharge (local to unit) duct static pressure transmitters shall be unidirectional, 0-5.0"w.c. range, or 1.2 times greater than fan pressure, which ever is greater.
   c. Mixed air and relief air box pressure transmitters shall be bidirectional, ±0.50"w.c. range for air handling units without heat wheels.
   d. Mixed air and relief air box pressure transmitters shall be bidirectional, ±1.00"w.c. range for air handling units with heat wheels.
   e. Building pressure transmitters shall be bidirectional, ±0.10"w.c. range.
   f. Space pressure transmitters shall be bidirectional, ±0.10"w.c. range.
   g. Fan Piezo Ring pressure transmitters shall be unidirectional, range verified with the fan manufacturer's published requirements at design maximum airflow, typically 0-10"w.c. range.
   h. Air filter pressure transmitters shall be unidirectional, 0-2.5"w.c. range.

L. Very Low Air Differential Pressure Transmitter
1. If not designated otherwise on the Points List, sensor ranges shall be as follows:
   a. Space pressure transmitters shall be bidirectional, ±0.1"w.c. range.
   b. Airflow monitoring station transmitters shall be unidirectional, 0-0.25"w.c. range.

M. Differential Pressure Transmitter Sensing Probe
1. For space mounted pressure sensing locations, provide minimum of 25 feet of ¼” polyethylene tubing between static pressure probe and pressure transmitter, coiled and wrapped neatly, to provide surge dampening for opening and closing of doors.
2. For outside air reference pressure sensing tubing, do not trim vinyl tubing to length, leave at full length to provide surge dampening of sensed pressure.
3. Outside air reference tubing exceeding 75 feet in length shall be increased in size from ¼” tubing to 3/8” OD, 0.020” wall hard copper tubing with solder fittings, and transitional fittings provided at each connected device.
4. Pressure sensor reference tubing applications:
    a. AHU downstream (remote from unit) duct static pressure transmitters shall reference the ceiling plenum or space if no ceiling is present.
    b. AHU discharge (local to unit) duct static pressure transmitters shall reference the mechanical room.
    c. Mixed air and relief air box pressure transmitters shall reference the outdoors (building exterior).
    d. Building pressure transmitters shall reference the outdoors (building exterior).
    e. Space pressure transmitters shall reference the adjacent space of isolation.

N. Automatic Control Dampers and Damper Actuators
1. Install dampers and actuators to be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator.
3. Install dampers straight and true, level in all planes, and square in all dimensions.
4. Install supplementary structural reinforcement for large multiple-section dampers if factory-furnished support alone cannot handle loading.
5. Attach field-installed actuator(s) to damper drive shaft.
6. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

O. Airflow Measurement
1. Flow meters shall be as scheduled on the plans and specified here-in.
2. The controls contractor shall provide flow meters and associated installation kits to the mechanical contractor for installation under other sections of the specification
3. Sensing elements shall be adequately supported for the velocities and spans encountered in the duct system.
4. Sensing element probe densities shall be sized according to manufacturer’s recommendations according to installed duct size.
    a. Enhanced probe densities are required for outside air flowmeters installed upstream of control dampers. Consult manufacturer’s recommendations for density required.
5. All necessary power requirements for the transmitter shall be provided under this section of the specification.
6. Temperature control contractor shall review with the mechanical contractor the required upstream and down steam requirements for the meter technology. In general unless the meter alters the flow profile as part of its technology then the following minimum general rules shall be followed for installation of sensing probes:
    a. Turning Vanes: 3 diameters downstream, 3 diameters upstream.
    b. Radius Elbows: 4 diameters downstream, 3 diameters upstream.
    c. Tees: 5 diameters downstream, 2 diameters upstream.
    d. Reducers: 2 diameters downstream, 2 diameters upstream.
    e. Expansions: 5 diameters downstream, 1 diameter upstream.

f. Ducted Fan Connections: 6 diameters downstream, 3 diameters upstream.
g. Plenum Fan Connections: 5 diameters downstream, 3 diameters upstream.

7. Include with the bid one each of any necessary configuration tools required to set up the meter if the setup cannot be accomplished from the meter electronics package itself to be turned over to the Owner upon project completion.

## 3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification. Comply with requirements for identification specified in Section 20 10 70 "Identification for Mechanical Systems."

## 3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

END OF SECTION 25 20 00

# SECTION 25 30 00 – HYDRONIC CONTROL EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Temperature Measurement
   2. Pressure Measurement
   3. Control Valves
   4. Flow Measurement
   5. Water Level Sensors
   6. Auxiliary equipment

C. Related Requirements:
   1. Section 25 00 00 TEMPERATURE CONTROL SYSTEM

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

2.2 INSERTION ELEMENT FLUID TEMPERATURE SENSOR

A. Sensor shall be tip sensitive 10,000 ohm Thermistor or 1,000 ohm RTD. Sensors shall be 6” long, with either 3/8” or ¼” diameter screwed or smooth shanks.

B. Thermistor element shall be 10,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

C. RTD element shall be 1,000 ohm, with a temperature coefficient of resistance (TCR) compatible with the system installed, ±1% at 25°C or ±0.36°F accuracy.

D. The housing shall be a weather tight cast aluminum utility box and stamped aluminum cover with a full gasket, or UV-resistant polycarbonate box with hinged cover and thumb latch.

E. Acceptable sensors are Precon KTW Series, BAPI BA/10K(1K) or approved equivalent.

2.3 INSERTION ELEMENT FLUID TEMPERATURE SENSOR WITH TRANSMITTER

A. Sensor shall be 100 ohm platinum RTD combined with a 4-20 mA transmitter factory matched and calibrated.

B. The element shall be 100 ohm platinum of 0°C, with a reference temperature coefficient of resistance equal to 0.00385 ohm/ohm/°C, Class B +/- 0.12 ohm at 0°C, per IEC Standard 751. RTD element may be a 2-wire or 3-wire type. RTD probes shall be 6” long with either 3/8” or ¼” diameter.

C. The transmitter shall be a high quality HVAC grade with an accuracy of +/- 0.1% of full scale or better (including linearity, hysteresis, and repeatability) referenced to mV input, with a drift of 0.1% of span per year or less. The transmitter shall be for a 100 ohm platinum RTD input and with a 4-20 mA output.

D. The housing shall be a weather tight cast aluminum ‘LB’ elbow or utility box, stamped aluminum cover, with a full gasket.

E. The RTD shall be factory calibrated to the specified ranges using a minimum of (3) points. Unless otherwise indicated the range shall be: 30°F - 80°F for chilled water, 30°F - 120°F for condenser water, and 30°F - 250°F for heating water and domestic hot water.

F. Chilled water transmitters shall be “sensor matched” and calibrated (with temperature) as an assembly with the actual RTD connected, for an accuracy of +/- 0.1°F plus 0.1% of span referenced to the actual temperature input.

G. Acceptable sensors are Weed model 723, Minco model S479PD, RdF model 2801, Graystone series TE500, or approved equivalent.

## 2.4 HYDRONIC DIFFERENTIAL PRESSURE TRANSMITTER

A. The transmitters shall be a high quality HVAC grade with an accuracy of +/- 0.25% of full scale or better (including linearity, hysteresis, and repeatability) with a drift of 0.5% of span per year or less. All wetted parts shall be 316 stainless steel for long life. Units shall be rated for an operating static pressure of 100 psig.

B. Enclosure shall be NEMA 4 weather tight construction with ½" conduit connection and 1/8" NPT process connections.

C. If not designated otherwise on the Points List, sensor ranges shall be as follows:

D. Pressure transmitters at pumps or in central plant mechanical rooms shall be 0-25 psid.

E. Pressure transmitters located at end-of run equipment for pump control shall be 0-10 psid.

F. Acceptable manufacturers are Setra model 230 with 3-valve manifold, Graystone model WP-D, or approved equivalent.

G. Transmitters that utilize independent pressure transducers on the high and low pressure lines are not allowed.

## 2.5 HYDRONIC GAUGE PRESSURE TRANSMITTER

A. The transmitters shall be a high quality HVAC grade with an accuracy of +/- 0.25% of full scale or better (including linearity, hysteresis, and repeatability) with thermal effects of zero shift of +/- 2.0%/100°F and +/- 1.5%/100°F. All wetted parts shall be 17-4 PH stainless steel for long life. Units shall be rated for shock of 200g operating, as tested per Mil-Std. 202, Method 213B, Cond. C.

B. Provide terminal block with conduit cover enclosure option and 1/8" MNPT process connection.

C. Sensor range shall be as indicated on Notes column of Points List.

D. Acceptable manufacturer is Setra model 209, or approved equivalent.

## 2.6 CONTROL VALVES

A. In general, the following types of valves shall be used unless otherwise indicated: Cooling valves shall be ball valves for 3" and smaller, and butterfly valves for 4" and larger. Hydronic heating valves shall be ball valves for 3" and smaller, and butterfly valves for 4" and larger. Steam heating valves shall be globe valves for all applications. Heating and cooling valves on unitary terminal equipment shall be ball-type zone valves.

1. Globe valves shall be Belimo, Schneider Electric, Johnson, Siemens, Bray or equivalent. Globe valves shall be threaded bronze body or flanged cast iron body, stainless steel stem, brass plug, composition disk, bronze seat, rated at 250 psi working pressure, and 35 psi differential pressure.
2. Ball valves shall be Belimo, Siemens, or Bray. Ball valves shall be threaded bronze body, chrome plated ball, blowout proof stem, Teflon seat, rated at 600 psi W-O-G working pressure, and 35 psi differential pressure.

a. Characterized discs that are Belimo, or equivalent, to 207 Cv-0.3, 208 Cv-0.46, and 209 Cv-0.8 shall not be used due the small orifice size and the protentional to clog.

3. Ball-type zone valves shall be Belimo. Ball-type zone valves shall be threaded forged brass body, chrome plated brass ball, brass stem, Teflon seat, rated at 360 psi, and 75 psi differential pressure.
4. Butterfly valves shall be Belimo or Bray. Butterfly valves shall be lug body style, cast iron body, aluminum bronze disk, EPDM seats, and stainless steel shaft. Valves to be selected for maximum open position of 60°.

B. Valve actuator requirements shall be as follows.

1. Torque rating shall be based on the valve manufacturers operating torque requirements at the design flows and pressure drops or shall be based on the manufacturers required shut off torque to achieve 100% flow shut off at pump shut off head on the system in which they are installed, whichever is greater.
2. For power-failure/safety applications, a mechanical, spring return mechanism shall be used. Non-mechanical forms such as battery back-up and capacitor discharge, are not acceptable. The normal position is the position that the actuator must fail to upon loss of control signal or power.
3. In general the following types of actuators shall be used unless otherwise indicated: Proportional spring return valves (4-20 mA, 0-10 VDC, 3-15 psi) will be used for heating coils on units with outdoor air connections and heat exchangers, refer to sequences or points list for fail-safe position. Proportional non-spring return valves (4-20 mA, 0-10 VDC, 3-15 psi) will be used for cooling coils and reheat coils. Triac or floating valves will only be allowed on VAV box reheat coils, fan coil units, terminal heating equipment, etc.
4. Two position valves shall be the full size of the pipe they are associated with unless otherwise specified.
5. Two way valve actuators shall be sized to close off tight against the full pump shut off head on the system in which they are installed.
6. Three way valve actuators shall be sized to close off tight in both directions against 2.5 times the valve pressure drop at full flow.
7. Electrical actuated valves shall be provided with Belimo, Bray or Siemens actuators. Actuators shall have current limiting circuitry incorporated in its design to prevent damage to the actuator. A gear release shall be provided on the motor to allow for manual override. Modulating actuators shall be rated for a 4-20 mA input signal. Actuators shall be rated for 24 VAC power. The units shall have visual mechanical position indication showing output shaft and vale position.

C. Modulating valve sizing shall be based on the following conditions.

1. General
   a. Flow rates for valve sizing shall be based upon the flow rates indicated on the equipment schedules on the drawings.
   b. Valve sizing shall consider the valve cavitation coefficient. In no case shall a valve be sized so that the pressure drop through the valve causes cavitation with fluid temperatures and pressures encountered in the system during start up or normal operation. If cavitation is possible in a single valve, select two control valves to be piped in series to avoid cavitation.
2. Water Valves:
   a. Minimum pressure drop 3 psi or equivalent to the waterside pressure drop of the coil it is associated with, whichever is greater.
   b. Maximum pressure drop 5 psi.
3. Steam Valves:

a. For valves in service on lines at or under 35 psig, target pressure drop is 42% inlet absolute pressure.
b. For valves in service on lines above 35 psig, target pressure drop is 80% inlet gauge pressure.
c. Valves shall be sized below critical Cv to prevent choked flow.

## 2.7 FLOW MEASUREMENT

A. Insertion Thermal Dispersion Fluid Flow Measurement
1. Technology: Insertion Vortex Shedding, pressure and temperature compensated
2. Range: 5 - 7000 SFPM
3. Mass Flow Rate Accuracy: +/-1% of reading 500-7000 SFPM; +/-2% of reading 100-500 SFPM
4. Pipe sizes: 1” and larger
5. Output: 4-20 mA signal proportional to flow mass rate
6. Installation: 3/4” thread-o-let installed by the Mechanical Contractor. Provide adequate room for removal/installation of meter
7. Flow meter shall be Onicon F-5100.

B. Insertion Electromagnetic Fluid Flow Measurement
1. Technology: Insertion electromagnetic
2. Range: 0.1 ft/sec to 20 ft/sec
3. Accuracy: +/-1% of reading between 2-20 ft/sec; +/-0.02 ft/sec below 2 ft/s
4. Pipe sizes: 4” and Larger
5. Output: 4-20 mA signal proportional to line velocity
6. Installation: 1-1/4” thread-o-let (1-1/2” for hot tap) installed by the Mechanical Contractor. Provide adequate room for removal/installation of meter
7. Flow meter shall be Onicon F-3500.

## 2.8 ELECTRONIC FLOW SWITCH

A. Furnish and install electronic flow switches a specified herein and shown on the drawings.

B. Sensor shall consist of a reference temperature probe and a heated temperature probe. The differential in temperature varies as the flow changes across the sensor. The sensor shall have a range of 0.5 to 5 fps. The trip set point shall be adjustable via a potentiometer on the circuit board.

C. The unit shall have a SPDT relay switch output with options for power input of 120 VAC, 24 VDC or VAC, or 240 VAC.

D. The housing shall be a general purpose LB enclosure with 1” FNPT electrical connection and 1” MNPT connection to the process piping.

E. Units shall be Ameritrol, Inc. Model FM-1000-voltage-02-S or approved equivalent.

PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions.

## 3.2 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the products specified in this section and related accessories to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

## 3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

## 3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:
   1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
   2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
   3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
   5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
   6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.

7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

C. Mount remote displays, switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches (1050 to 1800 mm) above the adjacent floor, grade, or service catwalk or platform.
   1. Make every effort to mount at 60 inches (1500 mm).

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 INSTALLATION OF INSERTION ELEMENT FLUID TEMPERATURE SENSOR

A. Provide sensors locations as indicated on the plans, flow diagrams, details, specifications, and sequence of operation.

B. Temperature sensor immersion well shall be brass or 316 **SS** 3/4” NPT or 1/2” NPT pipe connection size with 1/2” NPT female threads. Thermometer wells shall have an overall length of 6”. For larger pipe the fluid insertion length shall be 4-1/2”. For smaller pipes the insertion length shall be 2-1/2” with a 2” lag length. For general use, a straight stepped shank may be used, provided it is less than 70% of the manufactures critical velocity rating, otherwise use a heavy duty tapered shank to meet the required stiffness. Sensor wells internal bore shall match sensor provided.

C. The contractor shall be responsible for coordination, with the installing trade contractor of the other sections of the specification, the location of all thermometer wells and insertion depths required by this section. The tip of the sensor shall be completely in the process fluid. Thread-o-lets and any required bushings shall be coordinated the installing trade contractor. Sensor shall be installed with thermally conductive paste equal to Omegatherm -201 manufactured by Omega Engineering.

3.6 INSTALLATION OF DIFFERENTIAL PRESSURE SENSOR

A. The contractor shall provide for installation by others, isolation valves, snubbers, and access fittings to be used at all pressure transmitter and pressure sensor locations. The connections shall be configured by the installer so that the isolation valve isolates the sensor and calibration port (Pete’s plug, Schraeder valve, or access fitting) from the process monitored.

B. This section shall be responsible for coordination of the installation of all pressure sensor taps required under this section of the specification with other sections of the specification.

## 3.7 INSTALLATION OF CONTROL VALVE

A. Install pipe reducers for control valves smaller than line size. Position reducers as close to control valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation unless otherwise indicated.
   1. Do not provide unions for terminal equipment with copper pipe.

C. Test Plugs: Install pressure temperature test plugs in piping upstream and downstream of each control valve larger than 2” and where indicated on flow diagram or details.

D. Valve Orientation:
   1. Where possible, install valves that are installed in horizontal piping, with stems upright and not more than 15 degrees off of vertical, not inverted.
   2. Install valves in a position to allow full stem movement.

E. Clearance:
   1. Locate valves for easy access, and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
   2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

F. Threaded Valves:
   1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
   2. Align threads at point of assembly.
   3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
   4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

G. Flanged Valves:
   1. Align flange surfaces parallel.
   2. Assemble joints by sequencing bolt-tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

## 3.8 INSTALLATION OF FLOW INSTRUMENTS

A. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.

B. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.

C. Install in-line meters with flanges or unions to provide drop-in and -out installation.

D. Insertion Meters:

1. Install system process connections full size of meter connection and meter manufacturer requirements, but not less than NPS 1-1/2”. Provide NPT threaded bushing, the same material as the piping, if required by installation.
2. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

## 3.9 INSTALLATION OF ELECTRONIC FLOW SWITCH

A. Install system process connection full size of switch connection, but not less than NPS 1”. Provide NPT threaded bushing, the same material as the piping, if required by installation.

B. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

C. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

## 3.10 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

END OF SECTION 25 30 00

## SECTION 25 40 00 – AUXILIARY EQUIPMENT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Current Operated Switches
   2. Control Power Transformers
   3. Pressure Switches
   4. Terminal Blocks
   5. Relays
   6. Damper End Switches

B. Related Requirements:
   1. Section 25 00 00 TEMPERATURE CONTROL SYSTEM

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Refer to each induvial product specification.

## 2.3 CURRENT OPERATED SWITCHES

A. Adjustable Trip Current Switch
1. General: Adjustable trip current switches shall be used on belt driven or coupled equipment. Switches shall be provided with mounting hardware, and securely mounted and located such that they are easily adjustable without the possibility of shock from the starter components.
2. Current operated switch shall be capable of changing the state of an isolated dry contact or switch when a flow of current is sensed in the wire they are monitoring. The isolated output must be rated at 1 A at 30 VAC or VDC, they shall incorporate a status LED, and shall be UL listed. Trip points shall be between 0.5 A to 135 A, depending on motor size and application. Acceptable manufacturers and models are Veris H308, Veris H908, Functional Devices RIBXGH Series.

B. Fixed Trip Current Switch
1. General: Fixed trip current switches shall be used on direct drive equipment. Switches shall be securely mounted and located such that they are easily adjustable without the possibility of shock from the starter components.
2. Current operated switch shall be capable of changing the state of an isolated dry contact or switch when a flow of current is sensed in the wire they are monitoring. The isolated output must be rated at 1 A at 30 VAC or VDC, they shall incorporate a status LED, and shall be UL listed. Trip points shall be between 0.5 A to 135 A, depending on motor size and application. Acceptable manufacturers and models are Veris H300, Veris H900, Functional Devices RIBXGH Series.

C. Current Switch Integral Command Relay: Current operated switches may be provided with integral command relays as required to perform the indicated functions in the sequences of operation at the contractor’s option. In addition to the requirements set forth above for the current switch, relay contacts shall be SPST, rated for 5 A at 250 VAC minimum, sized for the application.

## 2.4 CONTROL POWER TRANSFORMERS

A. 24 VAC Control Power Transformers
1. Transformers shall be NEC Class 2 general purpose transformers with primary windings as required by the application and 24 VAC secondary windings rated for 40 VA at 100% power factor. Transformers shall be installed in a suitable enclosure to prevent contact with the primary and/or secondary terminals when the cover is on the enclosure. Where transformers are provided for installation by others, the transformers shall be provided mounted in the enclosure. The mounting arrangement shall be such that the terminals are accessible for connection without removing the transformer from the enclosure.
2. Transformers with higher VA ratings may be supplied but must be designed and installed to meet all requirements of NEC article 725 when used to serve Class 1, Class 2, or Class 3 low voltage circuits.
3. Where fuses are provided, a minimum of two (2) spare fuses of the same type and rating at each location.

B. 24 VAC Control Power Load Centers
1. Control Power Load Centers are used for distributed 24 VAC power supply of terminal control devices.

2. Load Centers shall have NEC Class 2 rated secondary winding circuit distribution. General purpose transformers up to 500 VA shall have 480/277/240/120 VAC primary windings and 24 VAC secondary windings. Primary input terminals shall be finger-safe. Secondary winding distribution shall have circuit breakers to provide 4 Amp overcurrent protection on isolated circuits. Each secondary winding distribution circuit shall have an isolation switch, status indicator light, and screw terminals for termination. Load Center shall be provided with NEMA 1 metal enclosure.
3. Load Center shall be Function Devices model PSH500A or approved equivalent.
4. Load Centers are provided by the Division 25 Contractor, secondary wiring is provided and performed by the Division 25 Contractor, primary wiring and conduit is provided and performed by the Division 26 Contractor.

## 2.5 PRESSURE SWITCHES

A. Air Differential Pressure Switch: Switches shall be arranged to actuate a snap acting single pole double throw switch based on the difference between two pressures as sensed by a diaphragm. The setpoint shall be adjustable between 0.05”w.c. and 12.0”w.c., with a progressive switching differential between 0.02”w.c. ±0.01”w.c. at minimum setpoint to 0.8”w.c. at maximum setpoint. Switch shall be rated to operate in ambient temperature of -40°F – 180°F, and diaphragm shall be rated for a maximum pressure of 0.5 psig. Switches shall be rated for a minimum of 300 VA pilot duty at 115 – 277 VAC, 15 A non-inductive load up to 277 VAC. Switches shall be rated for 100,000 cycles at maximum operating pressure and maximum electrical load. Enclosures shall be rated NEMA 1 and shall be provided with conduit connection and ¼” compression piping connections. Switches shall be Cleveland Controls model AFS-222 or approved equal.

B. Manual Reset Air Differential Pressure Switch: Switches shall be arranged to actuate a snap acting single pole single throw normally closed switch based on the difference between two pressures as sensed by a diaphragm with a manual reset button. The setpoint shall be adjustable between 0.40”w.c. ±0.06”w.c. and 12.0”w.c., with a progressive switching differential between 0.06”w.c. ±0.01”w.c. at minimum setpoint to 0.8”w.c. at maximum setpoint. Diaphragm shall be rated for a maximum pressure of 0.5 psig. Switches shall be rated for a minimum of 15A at 115 – 277 VAC. Switches shall be rated for 6,000 cycles at maximum operating pressure and maximum electrical load. Enclosures shall be rated NEMA 1 and shall be provided with conduit connection and ¼” compression piping connections. Switches shall be Cleveland Controls model AFS-460 or approved equal.

C. Air Differential Pressure Switch Sensing Probe: For all pressure sensing locations that are remote from the pressure switch, provide an appropriate static pressure sensing probe as described below. Connections between differential pressure switch and static pressure probes shall be made with 1/4” polyethylene tubing for all runs under 10 feet. For runs longer than 10 feet, run ¼” OD, 0.020” wall hard copper tubing with solder fittings. Terminate ends of copper tubing with ¼” ID to ¼” barbed adapter or ¼” compression to ¼” compression coupling for polyethylene final connections (within 9”) to device. Where compression fittings are used, use plastic tubing inserts for polyethylene tubing. Polyurethane tubing may not be used in any exposed applications, only within a control panel as it is not plenum rated.

D. For unit or duct mounted pressure sensing locations, provide static pressure probe with ¼" brass barb or compression connection and gasketed mounting flange. Static pressure probe shall be Mamac model A-520, Dwyer model A-489/491/493, or approved equal.

E. Hydronic Differential Pressure Switch: Switches shall be arranged to actuate a single pole double throw switch based on the difference between two pressures. Switches shall be bellows actuated. Switches shall be suitable for the working pressure of the system on which they are installed and shall have a minimum working pressure rating of 30 inches Hg vacuum to 100 psig. The setpoint shall be adjustable between 0 and 20 psig and the sensitivity shall be adjustable with a minimum setting of 1 psig. Switches shall be rated for a minimum of 5 amps at 120 VAC. Enclosures shall be rated NEMA 1 and shall be provided with termination points for conduit and piping connections. Switches shall be Mercoid series DPA or approved equal by United Electric or Penn.

## 2.6 TERMINAL BLOCKS

A. Fuse Holder Terminal Blocks: Terminal block shall be arranged to allow a fuse to be installed in the terminal strip between the entering and leaving wires of the termination point. Terminals shall be provided with LED, Neon, or mechanical fuse status indicators. Terminals shall be rated for the voltage and current of the circuit they are contained in at a minimum. Terminals shall be suitable for and mounted on a standard DIN EN 50022 mounting rail. Provide with accessories as required for a complete assembly. Acceptable models and manufacturers are as follows: Weidmuller SAKS Series, Entrelec MB10/12 Series, Phoenix UK5 Series.

B. Feed Through Terminal Blocks: Feed through terminal blocks shall be compatible with the special purpose terminals specified above and shall mount on the same DIN rail system. Terminals shall be clamp type terminals suitable for solid or stranded wire from #18 AWG to #12 AWG (minimum range). Terminals shall be rated for the voltage and current at which they are applied and shall be provided with all necessary end caps, separators, etc., required for a complete installation.

## 2.7 RELAYS

A. Plug-In General Purpose Relays
   1. Application: Plug-in general purpose relays shall be used in auxiliary panels and in controlled device power enclosures. Application may be for duplication of a signal for multiple devices, or for segegration of operating voltage of controlled devices.
   2. Description: Blade style 3PDT relay with socket and LED or mechanical indicator. Coil nominal (rated) voltage shall be dictated by application requirements, shall withstand 110% rated voltage continuous, have pull-in voltage of 80% of rated voltage, drop-out voltage of 30% rated voltage, and resistance of 103 ohms at 24 VAC / 10,800 ohms at 120 VAC. Contacts shall be silver cadmium oxide, rated for 7.5A at 120 VAC resistive load. Relays shall be Idec RH series with SH series socket or approved equal.

B. Track Mounted Relays
   1. Application: Track mounted relays are allowed for use in controlled device power enclosures whose space limitations prevent the use of plug-in relays, or for whose configuration prevent the use of enclosed relays.

2. Description: Track mounted relay with LED indicator, dual voltage coil for 24 VAC or 120 VAC, SPDT contact rated for 10A at 120 VAC resistive load. Relays shall be Air Products and Controls MR-800 series, Functional Devices RIMMNU1C, or approved equal.

C. Enclosed Relays
1. Application: Enclosed relays shall be used at controlled device power enclosures for remote operation of equipment.
2. Description: Enclosed relay with LED indicator, dual voltage coil for 24 VAC or 120 VAC, SPDT contact rated for 10A at 277 VAC resistive load. Relays shall be Functional Devices RIBU1C or approved equal.

D. Fan Safety Alarm Circuit Relays
1. Application: Fan safety alarm circuit relays are permitted for use of fan hardwired interlocks at the contractor’s option. If used, they shall be mounted in the auxiliary panel in which the air handling unit’s controller is mounted.
2. Description: Track mounted relay with LED indicators for power, master relay on, and status of input safeties, 24 VAC supply power (at 4A), SPST actuator control contact rated for 3A at 24 VAC, SPST fan safety control contact rated for 750 mA at 24 VAC, and one SPST dry contact for each monitored safety. Relays shall be Functional Devices RIBMNLB or approved equal.
a. For application with automatic reset low limit thermostats (see section 25 21 01), set board jumpers to enable latching circuit and manual reset button on low limit thermostat relay input.

E. Network Compatible Relays
1. Application: Network compatible relays are permitted for use only as specifically identified on the drawings, points list, or as expressly allowed by the engineer.

F. Time Delay Relays
1. Application: Time delay relays should normally be avoided, time delays shall be accommodated in programming where possible. In the event that time delay relays are required for a specific application, they shall be mounted in the auxiliary panel that has the controller for the controlled equipment, or in a specifically fabricated panel for the controlled equipment that is approved by the engineer.
2. Description: 11-blade style plug in relays requiring 24 VAC power supply, signal-triggered timing circuit, selectable timing functions (on-delay, off-delay, one-shot), adjustable time delay setting between 0.1 s – 600 hours, Form C output contacts, power and timer LED indicators, and UL listed. Relays shall be Idec RTE-B2 series or approved equal.

G. Latching Relays
1. Application: Latching relays are normally not used, except in applications where automatic reset low limit thermostats are allowed (see section 25 21 01) and the Fan Safety Alarm Circuit Relay is not used, where specifically required by the points list or sequence, or as specifically approved by the engineer.
2. Description: Blade style plug-in latching relay with permanent magnet self-holding function, with set and reset coils, check button, 3 A at 250 VAC. Relays shall be Idec RY2KS-UC or approved equal.

H. Relay & AC Current Switch Combo

1. Application: Enclosed relays & AC current switch combos shall be used at controlled device power enclosures for remote operation of equipment when status feedback is required.
2. Description: Enclosed relay/ac switch combination with adjustable threshold and override switch, solid state contact output, 24 VAC coil, SPDT contact rated for 20A at 277 VAC resistive load. Relays shall be Functional Devices RIBX24SBA or approved equal.

## 2.8 DAMPER END SWITCHES

A. Damper End Switches
1. End switches used for damper permissive fan safety circuits shall be safety limit switches, heavy-duty NEMA style, plug-in body. Enclosure shall be NEMA 4, 13 with ½" EMT conduit connection and ambient temperature rating 0°F to 230°F. Actuator head shall be rotary style, CW and CCW actuation, spring return , 4 in-lb operating torque, 13° max travel to operate contacts, 7° max travel to reset contacts, 90° max travel. Switch shall have two snap-acting contacts, 1 N.O. and 1 N.C.., 30A make at 120 VAC, 3.0A break at 120 VAC, 5A at 120 VAC continuous operating current. Operating lever shall be adjustable lever, 1.19 in. to 3 in. radius, with 0.63" diameter by 0.25" thick nylon roller (min.). End switch shall be Allen-Bradley 802T-AP or Square D 9007C54B2.
2. End switch and operating lever shall be installed such that contacts prove when damper blade is at 95% open. Operating lever roller shall contact damper blade directly, no contact with damper seal is acceptable. Where end switch cannot be directly mounted to duct wall, provide 12 gauge galvanized steel mounting bracket. Operating lever shall be Allen-Bradley 802T-W2 or Square D 9007HA23.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions.

## 3.2 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the products specified in this section and related accessories to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

C. Deliver the products specified in this section and related accessories to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

## 3.3 INSTALLATION OF CURRENT SWITCHES

A. For variable speed applications, trip point shall be set with motor at full speed under normal loading conditions (connected to system of service).

B. For variable speed applications, following trip point set at motor full speed, verify proof of operation at motor minimum speed. If current range between minimum and maximum speed prevents reliable proof indication in a single current switch, provide two switches (one for minimum speed and one for maximum speed) and program logic to accommodate proper status indication.

C. Split core current switches are preferred due to their ability to be changed without removal of phase conductors when the equipment has been placed into service. Solid core current transformers will be considered if there are space constraint considerations.

D. If motor current draw is less than listed minimum trip point for the current switch, wrap phase conductor around current switch the minimum number of passes to reach threshold trip current.

## 3.4 CLEANING AND PROTECTION

A. Clean surfaces and equipment of dust and debris prior to installation. Follow manufacturer's instructions.

END OF SECTION 25 40 00

# SECTION 25 50 00 – WIRING MATERIALS AND METHODS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Raceways
   2. Wiring

B. Related Requirements:
   1. Section 25 00 00 TEMPERATURE CONTROL SYSTEM
   2. Section 26 00 00 ELECTRICAL
   3. Section 27 00 00 COMMUNICATIONS

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer’s installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Manufacturer’s Operation and Maintenance instruction: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 CONTROL WIRE AND CABLE

A. A. Wire: Single conductor control wiring above 24 V.
   1. Branch Circuits: Minimum 12 AWG.
   2. Motor Interlock Wiring: Minimum 14 AWG.
   3. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.

4. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
5. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
6. Furnish on spools.

B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:
1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
4. Conductor Insulation Colors:
   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.
5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
7. Furnish on spools.

C. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:
1. Wire Size: Minimum 22 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Conductor Insulation Colors:
   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.
5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
7. Furnish on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Comply with following requirements for balanced twisted pair cable described in Section 27 15 13 "Communications Copper Horizontal Cabling."
   a. Category 6
   b. Plenum rated.
   c. Unique color that is different from other cables used on Project.

## 2.3 RACEWAYS

A. Comply with Section 26 05 33 "Raceway for Electrical Systems," Section 26 05 34 "Boxes for Electrical Systems," for installation.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct and piping systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:
   1. Comply with installation requirements in Section 26 05 19 “Low Voltage Electrical Power Conductors and Cables” for Power wiring and grounding.
   2. Comply with installation requirements in Section 27 15 13 "Communications Copper Horizontal Cabling" or LAN cabling.
   3. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
      a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
   4. Terminate wiring in a junction box
      a. Clamp cable over jacket in a junction box.
      b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.
   5. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
   6. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
   7. Use shielded cable to transmitters.
   8. Use shielded cable to temperature sensors.
   9. Motor Interlock Wiring:
      a. Stranded control wire shall be provided with crimp type spade terminators. Interlock circuit wiring shall be color-coded or numbered using an identical number on both ends of the conductor. Wire numbers shall be installed before conductors are pulled.

C. Conduit Installation

1. Comply with Section 26 05 33 "Raceway for Electrical Systems," Section 26 05 34 "Boxes for Electrical Systems," for installation.

D. Cable Tray Installation
   1. Comply with Section 26 05 36 “Cable Trays for Electrical Systems”.

## 3.3 CONDUIT SCHEDULE

A. Provide conduit and type per below
   1. Power wiring greater than 24 Volts – Conduit type per locations below
   2. Thermostat / sensor rough-in – EMT conduit
   3. Below 8’ AFF in unfinished spaces – EMT conduit
   4. Exposed to view in finished spaces – EMT conduit to be painted to match
   5. Connection to rotating equipment – jacketed flexible liquid tight (sealtite)
   6. Exterior above grade – Aluminum rigid conduit
   7. Exterior below grade – electrical PVC

B. Open wiring permitted with J-hook supports, maximum spacing 6 feet, for the following applications:
   1. Above lay-in ceilings
   2. Above 8’ AFF in unfinished spaces, unless noted otherwise.
   3. Bridal rings can be used when supporting a maximum of 6 wires.

**END OF SECTION 25 50 00**

## SECTION 25 95 00 - GENERAL

These sequences are intended to be performance based. Implementations that provide the same functional result using different underlying detailed logic will be acceptable.

Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup.

When a control loop is enabled or reenabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value.

A control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

When there are multiple outdoor air temperature sensors, the system shall use the valid sensor that most accurately represents the outdoor air conditions at the equipment being controlled.

Outdoor air temperature sensors at air-handler outdoor air intakes shall be considered valid only when the supply fan is proven ON and the unit is in occupied mode or in any other mode with the economizer enabled.

The outdoor air temperature used for optimum start, plant lockout, and other global sequences shall be the average of all valid sensor readings. If there are four or more valid outdoor air temperature sensors, discard the highest and lowest temperature readings.

The term “proven” (i.e., “proven ON”/“proven OFF”) shall mean that the equipment’s DI status point (where pro-vided, e.g., current switch, DP switch, or VFD status) matches the state set by the equipment’s DO command point.

The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

The term “control loop” or “loop” is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the guidelines in the following subsections shall be followed.

Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.).

Do not use the derivative term on any loops unless field tuning is not possible without it.

To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

All set points, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point, and the software point shall be used in all sequences. Exceptions shall be made for machine or life safety.

Every sensor input data point shall incorporate input value filtering, a time averaged value is preferable to change of value (COV) techniques. Due to the great variety in filtering requirements based on sensed value stability and process variable use, a prescriptive specification will not be provided in this guideline requirement. Rather, this requirement is to ensure that filtering is present in some form so that it may be adjusted during system tuning and acceptance, if so required, at no additional programming or cost.

Network dependent processes should be avoided. For control processes, particularly control loops, all input sensor readings, output device operations, and logic control algorithms shall reside in a single field controller. For particularly difficult applications, or for less critical applications, network dependent processes should be presented specifically to the Engineer during the Shop Drawing submittal for review and acceptance.

**Definitions:**

Adjustable (Adj.): Acknowledging that all values within a DDC system are adjustable using appropriate configuration software, the use of the term adjustable or adj. in the following statements has the specific meaning that the term described will be adjustable at the GUI without the need for any software. This adjustment may be password protected to limit access to an appropriate user level, and may use an adjustment mechanism similar to point overrides.

Deadband: The difference between two setpoint or configuration values during which no output function is performed.

Dewpoint Temperature: Dewpoint temperature (or also referred to simply as Dewpoint) is the saturation temperature of water in moist air, as evidenced by the temperature at which water will condense out of air. Dewpoint temperature is an evaluation of the absolute water content of moist air, so for control applications, it is used where moisture content of air needs to be maintained, such as humidification or dehumidification processes.

Differential: The range or units of measure that separate the enable point from the disable point.

Discharge Temperature: The temperature discharged from a piece of equipment, but not necessarily to an end use consumer.

Enthalpy: Thermodynamic quantity equivalent to the total heat content of air. It is usually used to evaluate if the outside air contains less heat than the return air, and determine whether to enable economizer.

Hard Wired Control: Control method using relays to enable and interrupt signals without the use of a controller.

Proportional: A set of signals that vary in a continuously linear relationship with each other. They may be direct or reverse acting.

Relative Humidity: Relative humidity is an evaluation of how much water vapor is present in air relative to the capacity of air at the current temperature and pressure to hold water. While it is a good measure of comfort levels, the temperature dependence of this value can make it an unstable control variable.

Supply Temperature: The temperature supplied to an occupied zone or terminal equipment point of use.

Temperature: The use of the common term temperature refers specifically to the psychrometric value dry bulb temperature.

Wet Bulb Temperature: The psychrometric property wet bulb temperature is the equilibrium temperature at which liquid water evaporates into the air at saturation. It can be measured with a thermometer that has a wick saturated in water. For control processes, it is typically used for the control of cooling towers since it is related to the evaporation of water in air. This is a different value from dewpoint temperature.

**Graphics:**

All graphics shall display time of day, date, outdoor air temperature and outdoor air relative humidity.

Cooling Plant Graphics:

Graphics showing cooling towers shall include outdoor air wet-bulb temperature. When applicable, cooling plant graphics shall show number of pressure reset requests.

Air Handling System Graphics:

When applicable, system graphics shall show number of incoming heating and cooling requests, pressure reset requests, total VAV flow, total VAV flow setpoint, Max VAV damper position, and Min VAV damper position.

VAV Graphics:

All VAV graphics shall include room name and number, and a link to the RTU which serves the VAV.

Air Handling Unit Summary Table:

A summary table shall include a list of all rooftop and/or air handling equipment. Columns shall include fan status, fan speed, static pressures, discharge temperature, valve and damper positions.

VAV Summary Table:

A summary table for each air handling system shall include a list of all VAVs served by the system. Columns shall include air flow, air flow setpoint, damper position, supply temperature, valve position, zone temperature, and zone temperature setpoint.

**Alarms**

Levels:

There shall be 4 levels of alarm

Level 1: Life-safety message

Level 2: Critical equipment message

Level 3: Urgent message

Level 4: Normal message

Maintenance Mode:

Operators shall have the ability to put any device (e.g., AHU) in/out of maintenance mode.

All alarms associated with a device in maintenance mode will be suppressed. Exception: Life safety alarms shall not be suppressed.

If a device is in maintenance mode, issue a daily Level 3 alarm at a scheduled time indicating that the device is still in maintenance mode.

Entry Delays:

All alarms shall have an adjustable delay time such that the alarm is not triggered unless the alarm condition is TRUE for the delay time. Default entry delays are as follows:

Level 1 alarms: 1 seconds

Level 2 alarms: 10 seconds

Level 3 alarms: 1 minutes

Level 4 alarms: 5 minutes

Exit Hysteresis:

Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.

Each analog alarm shall have an adjustable percent-of-limit-based hysteresis (default: 0% of the alarm threshold, i.e., no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.

Latching:

Any alarm can be configured as latching or non-latching. A latching alarm requires acknowledgement from the operators before it can return to normal, even if the exit deadband has been met. A non-latching alarm does not require acknowledgment. Default latching status is as follows:

Level 1 alarms: latching

Level 2 alarms: latching

Level 3 alarms: non-latching

Level 4 alarms: non-latching

Post-exit Suppression Period:

To limit alarms, any alarm may have an adjustable suppression period such that, if the alarm is triggered, its post-suppression timer is triggered and the alarm may not trigger again until the post-suppression timer has expired. Default suppression periods are as follows:

Level 1 alarms: 0 minutes

Level 2 alarms: 5 minutes

Level 3 alarms: 24 hours

Level 4 alarms: 7 days

For both latching and non-latching alarms, the operators may acknowledge the alarm. Acknowledging an alarm clears the alarm, the exit deadband, and suppression period. A device can go right back into alarm as soon as the entry delay elapses.

**VFD Speed Points**

The speed AO sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz, and 100% speed corresponds to maximum speed configured in the VFD.

Minimum and maximum speeds shall be configured in the VFDs such that the controlled device cannot operate outside of its design range when operating in Auto or Hand.

The controller shall not send an AO signal which is below the minimum allowed % speed of the device.

**Equipment Staging and Rotation**

Parallel equipment shall be lead/lag or lead/standby rotated to maintain even wear.

Two runtime points shall be defined for each equipment:

Lifetime Runtime: The cumulative runtime of the equipment since equipment start-up. This point shall not be readily resettable by operators.

Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.

Lead/lag equipment: Unless otherwise noted, identical parallel staged equipment (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the equipment with the most operating hours as determined by Staging Runtime is made the last stage equipment and the one with the least number of hours is made the lead stage equipment.

Lead/standby equipment:

Unless equipment runs continuously, parallel equipment that are 100% redundant shall be lead/standby alternated when more than one of the equipment is off so that the equipment with the most operating hours as determined by Staging Runtime is made the last stage equipment and the one with the least number of hours is made the earlier stage equipment.

If equipment runs continuously, lead/standby positions shall switch at an adjustable day of the week and time (e.g., every Tuesday at 10:00 am) based on Staging Runtime; standby equipment shall first be started and proven on before former lead equipment is changed to standby and shut off.

**Air Economizer High Limits**

Economizer shall be disabled whenever the outside air dry bulb temperature is above 65°F or the outside air dewpoint temperature is above 55°F.

Units provided with humidifiers shall not economize.

**Low Ambient Start-Up**

During low ambient conditions, when OA-T < 40°F, air handling units provided with preheat coils and introducing outside air shall reset their discharge air setpoint from 80°F down to the desired setpoint over a period of 20 minutes.

## SECTION 25 95 01 - SAFETIES

**Air-Handling Equipment:**

Safety devices include smoke detectors, low limit thermostat, low pressure and high-pressure switches.

All safety devices are hardwired such that a trip of any device would interrupt the signal to all the fans.

The low limit thermostat is also hardwired to all damper and valve actuators, such that a trip would interrupt power to the actuators returning them to their normal position.

Manual reset shall be required to resume normal operation.

Smoke detectors shall generate a Level 1 alarm, all other safeties shall generate a Level 2 alarm.

## SECTION 25 95 02 - GENERIC VENTILATION ZONES

**Zone Minimum Outside Air:**

For every zone that requires mechanical ventilation, the occupied minimum airflows and ventilation flows shall be as shown on the schedules and airflow diagrams.

## SECTION 25 95 03 - GENERIC THERMAL ZONES

This section applies to all single-zone systems and subzones of air-handling systems, such as VAV boxes, fan-powered boxes, etc.

**Set Points:**

Nominal Occupied Setpoint: 72°F

Occupied Cooling Setpoint: Nominal + 2.5°F = 74.5°F

Occupied Heating Setpoint: Nominal – 2.5°F = 69.5°F

Standby Cooling Setpoint: Nominal + 3°F = 75°F

Standby Heating Setpoint: Nominal - 3°F = 69°F

Unoccupied Cooling Setpoint: 79.5°F [76°F if high mass building]

Unoccupied Heating Setpoint: 59.5°F [66°F if high mass building]

The software shall prevent the following:

Overrides to the heating and cooling setpoints, only overrides to the nominal setpoint and the occupied and standby differentials are allowed.

The differential between the heating and cooling setpoint must never be less than 1°F.

The unoccupied heating set point from exceeding the occupied heating set point.

The unoccupied cooling set point from being less than the occupied cooling set point.

Where the zone has a local set point adjustment knob/button:

The set point adjustment offsets established by the occupant shall be software points that are persistent (e.g., not reset daily), but the actual offset used in control logic shall be adjusted based on limits and modes as describe below.

Adjustments made at the space sensor shall modify the Nominal Occupied Setpoint, while the Cooling and Heating setpoints shall remain a fixed range from the Nominal Setpoint. The setpoint adjustment shall be limited to 2°F above and 2°F below Nominal Setpoint.

Local Override:

When thermostat override buttons are depressed, the call for occupied mode operation shall be sent to the zone group control for 60 minutes.

**Control Loops:**

Two separate control loops, the cooling loop and the heating loop, shall operate to maintain space temperature at set point.

The heating loop shall be enabled whenever the space temperature is below the current zone heating set-point temperature and disabled when space temperature is above the current zone nominal set point temperature and the loop output is zero for 30 seconds.

The heating loop shall maintain the space temperature at the active heating set point. The output of the loop shall be a software point ranging from 0% (no heating) to 100% (full heating).

The cooling loop shall be enabled whenever the space temperature is above the current zone cooling set-point temperature and disabled when space temperature is below the current zone nominal set-point temperature and the loop output is zero for 30 seconds.

The cooling loop shall maintain the space temperature at the active cooling set point. The output of the loop shall be a software point ranging from 0% (no cooling) to 100% (full cooling).

Loops shall use proportional + integral logic or other technology with similar performance. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable by the operator.

See other sections for how the outputs from these loops are used.

**Zone State**

Heating:

When the output of the space heating control loop is nonzero and the output of the cooling loop is equal to zero.

Cooling:

When the output of the space cooling control loop is nonzero and the output of the heating loop is equal to zero.

Deadband:

When not in either heating or cooling.

**Schedules:**

General Building Schedule:

Mon-Fri: 6am-6pm

Sat: 8am-4pm

Sun: 8am-12pm

Office Schedule:

Mon-Fri: 7am-6pm

Sat-Sun: Off

Gym Schedule:

Mon-Fri: 10am-9pm

Sat-Sun: Off

Event Schedule:

Mon-Fri: Off

Sat-Sun: Off

**Operating Modes:**

Occupied Mode:

A zone group is in the occupied mode when any of the following is true:

The time of day is between the zone group's scheduled occupied start and stop times.

The schedules have been overridden by the occupant over-ride system.

Occupant override system is a Web-based system to allow individuals to modify the schedule of their zone. (This is a best-in-class feature that will not be available on all projects)

Any zone local override timer (initiated by local override button) is nonzero.

Warm-Up Mode:

For each zone, the BAS shall calculate the required warm-up time based on the zone's occupied heating set point, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned ON or OFF by a software switch to allow tuning to be stopped after the system has been trained. Warm-up mode shall start based on the zone with the longest calculated warm-up time requirement, but no earlier than 3 hours before the start of the scheduled occupied period and shall end at the scheduled occupied start hour.

Cooldown Mode:

For each zone, the BAS shall calculate the required cooldown time based on the zone's occupied cooling set point, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. Zones where the window switch indicates that a window is open shall be ignored. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned ON or OFF by a software switch to allow tuning to be stopped after the system has been trained. Cooldown mode shall start based on the zone with the longest calculated cooldown time requirement, but no earlier than 3 hours before the start of the scheduled occupied period and shall end at the scheduled occupied start hour.

Setback Mode:

During unoccupied mode, if any 5 zones (or all zones if fewer than 5) in the zone group fall 2°F below their unoccupied heating set points, or if the average zone temperature of the zone group falls 2°F below the average unoccupied heating set point, the zone group shall enter set-back mode until all spaces in the zone group are above their unoccupied set points.

Freeze Protection Setback Mode:

During unoccupied mode, if any single zone falls below 40°F, the zone group shall enter setback mode until all zones are above 45°F and a Level 3 alarm shall be set.

Setup Mode:

During unoccupied mode, if any 5 zones (or all zones if fewer than 5) in the zone group rise 2°F above their unoccupied cooling set points, or if the average zone temperature of the zone group rises above the average unoccupied cooling set point, the zone group shall enter setup mode until all spaces in the zone group are below their unoccupied set points.

Unoccupied Mode:

When the zone group is not in any other mode.

## SECTION 25 95 04 - VAV TERMINAL UNIT WITH REHEAT

**Overview:**

The zone terminal unit maintains room setpoint using a deadband, two different setpoint are used for heating and cooling. As heating is needed, the unit resets the supply temperature setpoint up to 20°F above the room heating setpoint; once the supply temperature setpoint reaches its maximum, the unit resets the supply flow from Minimum to Heating Maximum. As cooling is needed, the flow is increased from Minimum to Cooling Maximum.

When a $CO_2$ sensor is available, flow setpoint is also reset based on zone $CO_2$ levels. If the zone $CO_2$ rises, the temperature control is overridden, and the flow is increased up to VAVmax.

The terminal units send Heating, Cooling, and Pressure Requests to the air handler. The air handler sums all the requests and resets its setpoints using control loop logic.

The terminal unit is provided with a modulating damper, flow measuring station, modulating heating coil, a discharge temperature sensor, a ceiling mounted occupancy sensor (when available by div26), a zone $CO_2$ sensor (when listed on the schedules) and a zone temperature sensor.

**Zone Occupancy:**

The zone is part of a zone group, see “Zone Groups” for operating modes.

When zone occupancy sensors are available:

The zone is allowed to independently go into Standby mode if the zone group is occupied and the sensor does not detect motion for 15 minutes. When in Standby mode, the setpoints are relaxed and minimum airflow is set to the unoccupied value.

**Zone Temperature Setpoint:**

See “Generic Thermal Zones” for set points.

**Optimum Start:**

Conditioning of the zone shall start prior to occupancy such that the zones are at setpoint when the schedule switches to occupied.

See “Zone Groups” for zone cooldown and warmup.

**Airflow Control:**

For zones with CO2 sensor or occupancy sensor, See “Generic Ventilation Zones” for minimum airflow setpoint reset.

The airflow setpoint is reset based on the heating, cooling, and demand control ventilation commands. The sequence calling for the greatest airflow shall be used for control.

Minimum Airflow Setpoint: The terminal unit minimum flow is reset based on occupancy.

When the VAV is operating in Occupied mode, VAVmin shall be as scheduled.

When the VAV is operating in Standby or any mode other than Occupied, VAVmin will be adjusted such that the rooftop unit does not operate below 30% of its maximum scheduled flow.

VAVmin = MAX (0, MIN (VAVmax*0.3, (VAVflow + RTUmax*0.3 – RTUflow)))

Where:

VAVmax is the VAV scheduled maximum flow.

VAVflow is the instantaneous airflow reading.

RTUmax is the RTU scheduled maximum supply flow.

RTUflow is the sum of all the instantaneous VAV airflows served by the same RTU.

The flow setpoint is reset between VAVmin and VAVmax based on the heating, cooling, and demand control ventilation commands. The sequence calling for the most flow shall be used for control.

Airflow PID: An internal flow sensor provides an input to a control loop, the loop setpoint is determined by the sequence that requires the most airflow, and the loop output modulates the damper from closed to open.

**Zone Temperature Control:**

Zone Temperature is controlled by modulating airflow through the terminal unit and the reheat valve. Minimum Flow will be reset based on occupancy status.

See “Generic Thermal Zones” for control loops and setpoints.

Zone Cooling:

When the zone state is cooling, the cooling loop output shall be mapped to the airflow set point from the cooling minimum to the cooling maximum airflow set points.

If supply air temperature from the air handler is greater than room temperature, cooling supply airflow set point shall be no higher than the vav minimum.

Heating coil is OFF.

Zone Heating:

When the zone state is heating, the heating loop shall maintain space temperature at the heating set point as follows:

From 0% to 50%, the heating-loop output shall reset the discharge temperature set point from the current AHU SAT set point to a maximum of 20°F above space temperature set point. The airflow set point shall be the heating minimum.

From 51% to 100%, if the DAT is greater than room temperature plus 3°C (5°F), the heating-loop output shall reset the airflow set point from the heating minimum airflow set point to the heating maximum airflow set point.

The heating coil shall be modulated to maintain the discharge temperature at setpoint. (Directly controlling heating off the zone temperature control loop is not acceptable).

Zone Deadband:

When the zone state is deadband, the active airflow set point shall be the minimum airflow set point. Heating coil is disabled.

**Cooling DAT Request:**

Up to 3 cooling requests are sent to the air handler. One for each of the following:

If the zone is 3°F above setpoint for 2 minutes (2°F differential), send 3 requests.

Else if the zone is 1°F above setpoint for 2 minutes (1°F differential), send 2 requests.

Else if the cooling loop is more than 95% (10% differential), send 1 request.

Else if the cooling loop is less than 95%, send 0 requests.

**Heating DAT Request:**

Up to 3 heating requests are send to the air handler.

If the zone is 3°F below setpoint for 2 minutes (2°F differential), send 3 requests.

Else if the zone is 1°F below setpoint for 2 minutes (1°F differential), send 2 requests

Else if the heating loop is more than 95% (10% differential), send 1 request.

Else if the heating loop is less than 95%, send 0 requests.

**Duct Static Pressure Request:**

Up to 2 pressure increase requests are sent to the air handler. One for each of the following:

Damper is 100% open. Cease request when damper is less than 85% open.

Zone is 2°F above setpoint. Cease request when zone is within 1°F of setpoint.

Importance Multiplier for pressure requests shall be limited to 1 or less, if set greater than 1 the air handler will remain at max pressure.

**Heating Hot Water Plant Pressure Request:**

If the valve position is greater than 95%, send 1 request until the valve position is less than 85%.

Else if the valve position is less than 95%, send 0 requests.

Importance Multiplier for pressure requests shall be limited to 1 or less, if set greater than 1 the heating loop will remain at max pressure.

**Multiple VAVs Serving One Room:**

When multiple terminal units serve a common room, one unit is setup as the leader and performs the Zone Temperature Control calculations. The rest of the units are setup as followers, using the Zone Cooling PID and Zone Cooling PID outputs from the leader unit.

When multiple zone temperature sensors are installed, the average of all sensors is used for control.

**Alarms:**

Low Airflow:

If the measured airflow is less than 70% of set point for 5 minutes while set point is greater than zero, generate a Level 3 alarm.

If the measured airflow is less than 50% of set point for 5 minutes while set point is greater than zero, generate a Level 2 alarm.

If a zone has an Importance-Multiplier of 0 for its static pressure request, low airflow alarms shall be suppressed for that zone.

Low Discharge Air Temperature:

If heating hot-water plant is proven ON, and the DAT is 15°F less than set point for 10 minutes, generate a Level 3 alarm.

If heating hot-water plant is proven ON, and the DAT is 30°F less than set point for 10 minutes, generate a Level 2 alarm.

If a zone has an Importance-Multiplier of 0 for its hot-water reset request, low-DAT alarms shall be suppressed for that zone.

Airflow Sensor Calibration:

If the fan serving the zone has been OFF for 10 minutes, and airflow sensor reading is above 10% of the cooling maximum airflow set point, generate a Level 3 alarm.

Leaking Damper:

If the damper position is 0% and airflow sensor reading is 10% of the cooling maximum airflow set point for 10 minutes, generate a Level 4 alarm.

Leaking Valve:

If the valve position is 0% for 15 minutes, DAT is above AHU DAT by 10°F, and the fan serving the zone is proven ON, generate a Level 4 alarm.

CO2 Sensor Malfunction:

If the zone CO2 is above 1900ppm or below 200ppm for 24hrs, generate a Level 4 alarm.

**Testing/Commissioning Overrides:**

Provide software switches that interlock to a system level point to
force zone airflow set point to zero,
force zone airflow set point to VAVcool-max,
force zone airflow set point to VAVmin,
force zone airflow set point to VAVheat-max,
force damper full closed/open,
force heating to OFF/closed, and
reset request-hours accumulator point to zero (provide one point for each reset type listed above).

## SECTION 25 95 05 - MULTIPLE-ZONE VAV AIR HANDLING UNIT (AHU-1 & AHU-2)

**Overview:**

This variable volume air handler serves terminal units with reheat.

The unit is provided with modulating supply and relief fans, steam and chilled water coils, a minimum outside air damper, modulating economizer, return air, and relief air dampers, and filters.

Discharge pressure and temperature are reset based on zone demand. The temperature reset is disabled when ambient conditions are humid to prevent high space humidity.

Ventilation is controlled by opening the minimum outside air damper and modulating the return damper to maintain ventilation pressure.

Building static pressure is controlled by modulating the relief damper and relief fan speed. When multiple relief fans serve a common air volume, the dampers and fans are grouped and controlled as a single system.

The economizer damper modulates to maintain mixed air temperature at setpoint when enabled.

The supply fan modulates to maintain discharge pressure.

The unit sends plant enable and pressure reset requests to the cooling and heating plants based on discharge temperature and valve position.

**Safeties:**

See airflow diagrams for location of safety devices. See “Safeties” above for details.

**Schedule:**

See “Zone Groups” for scheduling.

**Discharge Air Temperature Control:**

Discharge Air Temperature Setpoint:

Occupied mode:

When outside air dewpoint temperature is above 55°F the set point is set to 55°F. When outside air dewpoint temperature is below 54°F the setpoint is allowed to reset based on the zone cooling and heating requests using a control loop.

The setpoint reset control loop is enabled when outside air dewpoint is below 54°F and the fan is proved ON.

The controller subtracts the sum of all heating requests from the sum of all cooling requests and uses the result as an input to a reverse acting control loop with a setpoint of zero. The loop output is mapped to reset the discharge air setpoint from 55°F when the loop is at 0%, to 65°F when the loop is at 100%

Cooldown mode:

The set point shall be set to 55°F.

Warm-up and setback modes:

The setpoint shall be set to 85°F

Discharge Air Temperature PID:

Discharge air temperature shall be controlled to set point using a control loop whose output is mapped to control the cooling coil.

**Chilled Water Valve Control:**

The valve modulates to maintain discharge air temperature when the fan is proved ON and outside air temperature is above 55°F.

If the fan status is OFF or the outside air temperature is below 54°F the valve is locked out.

**Mixed Air Temperature Control (Economizer):**

Mixed Air Temperature Setpoint:

The setpoint shall be calculated by subtracting fan heat from the discharge air temperature setpoint. Where fan heat is calculated by subtracting cooling coil leaving air temperature from discharge air temperature.

MAT-SP = DAT-SP – Max (3, (DA-T – CC-T))

Mixed Air Temperature PID:

The loop is enabled when economizer is enabled and the heating valve is closed. If economizer is disabled or the heating valve is open, then the loop is disabled.

Mixed air temperature shall be controlled to setpoint using a control loop whose output modulates the economizer damper.

The loop output is mapped to command the economizer damper from 0% to 100% as the control loop goes from 0% to 100%.

**Economizer Damper Control:**

The damper is commanded closed when the schedule is unoccupied, or when the unit is off, or when economizer is disabled, or when the heating valve is open, or when any safety is tripped.

When enabled the damper modulates from 0% to 100% as commanded by the output of the mixed air temperature PID.

**Ventilation Control:**

Differential Pressure Balancing:

The minimum differential pressure set point shall be determined by the balancer as follows:

Open the minimum outside air damper and the return damper

Set all VAVs to max flow and allow the supply fan to stabilize, then override supply fan speed.

If outside airflow is above design minimum, adjust the min outside air damper linkage.

If outside airflow is below design minimum, adjust the return air damper position.

Record the pressure across the damper as the design minimum pressure setpoint (DesMinDP).

For zone groups with demand control ventilation:

Reduce supply fan speed until absolute minimum outside air is introduced (60% of design minimum when not scheduled).

Record the pressure across the damper as the absolute minimum pressure setpoint (AbsMinDP)

Differential Pressure Set Point:

For units without demand control ventilation, MinDPsp = DesMinDP.

For units using demand control ventilation logic, MinDPsp is reset between AbsMinDP and DesMinDP based on zone ventilation demand.

See “Generic Ventilation Zones” for outside air requirements and resets.

Differential Pressure PID:

The loop is enabled when the fan is proven ON and the unit is in occupied mode, and disabled otherwise.

A differential pressure sensor is located across the minimum outside air damper.

The pressure sensor provides an input to a control loop, the loop set point is the MinDPsp calculated above, and the loop output is used to modulate the return damper.

**Building Static Pressure Control:**

Building static pressure shall be time averaged with a sliding 5-minute window and 15 second sampling rate (to dampen fluctuations). The averaged value shall be that displayed and used for control.

A control loop maintains the building pressure at a set point of 0.03 in. of water with an output ranging from 0% to 100%.

The loop is enabled when building pressure rises above 0.05 in. of water.

The loop is disabled and output set to zero when building pressure drops below 0.01 in. of water.

The loop output is mapped to all the relief fans and relief dampers serving a common/shared volume.

**Minimum Outside Air Damper Control:**

A modulating damper is used to allow for slow introduction of ventilation air. When the supply fan is proved ON and the schedule switches to occupied, the damper is commanded from 0% to 100% over a period of 20 minutes to allow the temperature control loops enough time to react. If the fan is OFF or the schedule is not occupied the damper is commanded closed.

**Return Air Damper Control**

The damper modulates to maintain ventilation pressure when the supply fan is proved ON and the unit is in occupied mode, and it is commanded fully open otherwise.

The output of the ventilation pressure loop is mapped to control the damper from 0% to MaxRA-P as required to maintain pressure setpoint.

MaxRA-P is linearly reset from 100% when the economizer damper is closed to 0% when the economizer damper is fully open.

**Relief Air Damper Control:**

All relief dampers serving a common/shared air volume shall be grouped and controlled as if they were one system, even if they are associated with different AHUs.

When the associated relief fan is proved ON, the relief damper modulates to maintain building pressure. The building pressure loop output is mapped to control the damper from 10% when loop output is 0% to 100% when loop output is 30%.

**Discharge Air Static Pressure Control:**

Discharge Air Static Pressure Setpoint:

The set point shall be reset using control loop logic. Each terminal unit sends up to 2 pressure requests to the air handler, the unit sums all the requests and uses the sum as an input to a control loop, the loop output is used to reset the set point from SPmin to SPmax.

Use 0.3” w.c. and 1.2” w.c as initial values.

Discharge Air Static Pressure PID:

When the fan is proven ON, the loop is enabled.

A differential pressure sensor is located downstream in the duct such that the maximum pressure reading is 1.2” w.c. when all the zones are satisfied. The sensor references zone pressure.

The static pressure sensor provides an input to the loop, the loop set point is as calculated above, and the loop output is used to modulate fan speed.

**Supply Fan Control:**

Fan Enable:

The fan shall run when the system is in cooldown mode, setup mode, or occupied mode.

If there are any VAV-reheat boxes on perimeter zones, supply fan shall run in all modes except unoccupied.

Fan Speed Control:

Supply fan speed is controlled to maintain duct static pressure at set point when the fan is proven ON. The static pressure loop output shall be mapped control the fan speed from 30% to 100%.

**Relief Fan Control:**

All operating relief fans that serve a common/shared air volume shall be grouped and controlled as if they were one system, running at the same speed and using the same control loop, even if they are associated with different AHUs.

Fan Enable:

A relief fan shall be enabled when its associated supply fan is proven ON and the building pressure control loop is enabled, and shall be disabled otherwise.

Fan Speed Control:

Fan speed signal to all operating fans in the relief system group shall be the same and shall be equal to the building pressure loop signal but no less than the minimum speed.

**Preheat Air Temperature Control:**

Preheat temperature is maintained at 55°F in order to prevent freezing of the coils downstream.

When the schedule goes occupied and the unit starts introducing outside air, the preheat setpoint is temporarily increased to 85°F and it resets down to 55°F over a period of 20 minutes.

Preheat Temp PID:

The control loop is enabled when outside air temperature is below 45°F and disabled above 50°F.

An averaging sensor downstream of the preheat coil is used for control. The loop output is mapped to the preheat valve.

**Preheat Valve Control:**

The valve modulates from 0% to 100% as commanded by the preheat loop.

The valve shall be limited to a minimum position which resets from 0% when outside air temperature is 40°F to 30% when the outside air temperature is 15°F.

When outside air is above 50°F the valve is locked closed.

**Chilled Water Pressure Reset Request:**

If the supply air temperature exceeds the supply air temperature set point by 5°F for 2 minutes, send 3 requests.

Else if the supply air temperature exceeds the supply air temperature set point by 3°F for 2 minutes, send 2 requests.

Else if the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 85%.

Else if the CHW valve position is less than 95%, send 0 requests.

**Call for Cooling:**

Send the chiller plant that serves the system a chiller plant request as follows:

If the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 10%.

Else if the CHW valve position is less than 95%, send 0 requests.

The chiller plant will start when there is at least one request for 5 minutes, and stop when there are no requests for 5 minutes, after a minimum run-time has elapsed.

Actuation of the chilled water valve resulting from a low limit / freeze stat safety shall not produce a call for cooling request. However, this condition shall result in the enabling of a chilled water system pump to circulate water. See the chilled water plant pump control sequence.

**Hot Water Pressure Reset Request:**

If the supply air temperature is 30°F less than set point for 5 minutes, send 3 requests.

Else if the supply air temperature is 15°F less than set point for 5 minutes, send 2 requests.

Else if HW valve position is greater than 95%, send 1 request until the HW valve position is less than 85%.

Else if the HW valve position is less than 95%, send 0 requests.

**Call for Heating:**

Send the heating hot-water plant that serves the AHU a heating hot-water plant request as follows:

If the HW valve position is greater than 95%, send 1 request until the HW valve position is less than 10%.

Else if the HW valve position is less than 95%, send 0 requests.

The hot water plant will start when there is at least one request for 5 minutes, and stop when there are no requests for 5 minutes, after a minimum run-time has elapsed.

**Alarms:**

Fan/Pump/Wheel Alarm:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

Filter Pressure:

Differential pressure drop exceeds alarm limit: Level 4.

The alarm limit shall vary with total airflow (if available; use fan speed if total airflow is not known) as follows:

DPx = DP100*(x)^1.4

Where DP100 is the high-limit pressure drop at design airflow (determine limit from filter manufacturer) and DPx is the high limit at the current airflow rate x (expressed as a fraction). For instance, the set point at 50% of design airflow would be (0.5)^1.4, or 38% of the design high-limit pressure drop.

<u>Low Mixed Air Temperature:</u>

Air temperature entering the cooling coil is below 50°F: Level 2.

<u>High discharge pressure</u>

Pressure is more than 0.3 in. of water above setpoint: Level 4.

<u>Low discharge pressure</u>

Pressure is less than 0.2 in. of water below setpoint: Level 3.

<u>High building pressure</u>

Pressure is more than 0.10in. of water: Level 3.

<u>Low building pressure</u>

Pressure is less than 0.0 in. of water (i.e., negative): Level 4.

<u>Airflow sensor malfunction:</u>

Ventilation flow is 20% greater than the total VAV airflow for 60 minutes: Level 4.

<u>Insufficient ventilation:</u>

Ventilation flow is 20% below set point for 60 minutes: Level 4.

## SECTION 25 95 06 - SINGLE-ZONE VAV AIR HANDLING UNIT (AHU-3)

**<u>Overview:</u>**

This variable volume air handler operates as a single zone unit. The unit is provided with modulating supply and relief fans, chilled water cooling, hot water heating, a single modulating outside air damper, relief, and return dampers, and filters.

Supply fan speed and discharge temperature are reset based on zone demand and ventilation requirements.

Ventilation is controlled by resetting the outside air damper between balanced positions based on supply fan speed.

The return air damper controls equal and opposite to the outside air damper.

Economizer modulates the outside air damper to maintain mixed air temperature.

Building pressurization is maintained using a pressure sensor to control relief fan speed. When multiple relief fans serve a common volume, they all control together as a single system.

The unit sends plant enable and pressure reset requests to the cooling and heating plants based on discharge temperature and valve position.

**<u>Safeties:</u>**

See airflow diagrams for location of safety devices. See “Safeties” above for details.

**Schedule:**

See “Zone Groups” for scheduling.

**Discharge Air Temperature Control:**

Cooling:

The loop is enabled when the supply fan is proved ON and outside air dewpoint is above 56°F or outside air temperature is above 75°F. If outside air dewpoint is below 55°F and outside air temperature is below 74°F or the supply fan is OFF the loop is disabled.

Discharge air temperature set point:

The setpoint is set to 74°F when outside air dewpoint is below 55°F, and to 55°F when the outside air dewpoint is above 56°F.

Cooling PID:

An averaging sensor downstream of the cooling coil provides an input to the control loop, the loop setpoint is as determined above, and the loop output is mapped to modulate the cooling valve.

Reheat:

The reheat coil provides room neutral air when the cooling coil is dehumidifying.

The loop is enabled when the supply fan is proved ON and the cooling coil is maintaining 55°F discharge.

Reheat PID:

A duct temperature sensor at the unit discharge provides an input to the control loop. The loop setpoint is constant 70°F, and the loop output is mapped to modulate the reheat valve.

**Preheat Air Temperature Control:**

The loop is enabled when the supply fan is proved ON and the outside air temperature is below 54°F. If outside air temperature is above 55°F of the supply fan is OFF the loop is disabled.

Temperature leaving the preheat coil is maintained at a constant setpoint of 55°F by modulating the preheat valve.

When the unit is first enabled during ambient temperatures below 40°F, the preheat setpoint is temporarily increased to 85°F and it resets down to 55°F over a period of 20 minutes.

**Chilled Water Valve Control:**

The valve modulates to maintain leaving air temperature when the supply fan is proved ON and cooling enabled; it is commanded closed otherwise.

**Preheat Valve Control:**

The valve modulates to maintain preheat air temperature when the supply fan is proved ON.

The valve shall be limited to a minimum position which resets from 0% when outside air temperature is 40°F to 30% when the outside air temperature is 15°F.

**Reheat Valve Control:**

The valve modulates to maintain discharge temperature when the supply fan is proved ON.

The valve shall be limited to a minimum position which resets from 0% when outside air temperature is 40°F to 30% when the outside air temperature is 15°F.

**Supply Fan Control:**

Fan Enable:

The supply fan shall run whenever the unit is in any mode other than unoccupied mode.

Fan Speed Control:

Provide a ramp function to prevent changes in fan speed of more than 10% per minute.

Minimum and maximum fan speeds shall be as follows:

MinSpeed: The speed that provides supply airflow equal to design outside air

MaxHeatSpeed: The speed that provides supply airflow equal to the design heating airflow scheduled on plans. If no heating airflow is provided on plans, default to half of the maximum cooling speed.

MaxCoolSpeed: The speed that provides supply airflow equal to the design cooling airflow scheduled on plans.

Heating:

For a heating-loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

For a heating-loop signal of 50% to 0%, fan speed set point is MinSpeed.

Deadband:

In deadband, fan speed set point is MinSpeed.

Cooling:

For a cooling-loop signal of 0% to 50%, fan speed is MinSpeed

For a cooling-loop signal of 50% to 100%, fan speed is reset from MinSpeed to MaxCoolSpeed.

**Preheat Air Temperature Control:**

Preheat temperature is maintained at 55°F in order to prevent freezing of the coils downstream.

When the schedule goes occupied and the unit starts introducing outside air, the preheat setpoint is temporarily increased to 85°F and it resets down to 55°F over a period of 20 minutes.

Preheat Temp PID:

The control loop is enabled when outside air temperature is below 45°F and disabled above 50°F.

An averaging sensor downstream of the preheat coil is used for control. The loop output is mapped to the preheat valve.

**Preheat Valve Control:**

The valve modulates from 0% to 100% as commanded by the preheat loop.

The valve shall be limited to a minimum position which resets from 0% when outside air temperature is 40°F to 30% when the outside air temperature is 15°F.

When outside air is above 50°F the valve is locked closed.

**Preheat Coil Pump Control:**

The pump is enabled when the preheat valve is more than 5% open or when the outside air temperature is below 40°F and disabled when the valve is closed and the outside air temperature is above 42°F.

In the event of a Freezestat, the pump is commanded to start.

**Ventilation Control:**

Differential Pressure Balancing:

The minimum differential pressure set point shall be determined by the balancer as follows:

Open the minimum outside air damper and the return damper

Set the supply fan to maximum cooling flow.

If outside airflow is above design minimum, adjust the min outside air damper linkage.

If outside airflow is below design minimum, adjust the return air damper position.

Record the pressure across the damper as the design minimum pressure setpoint (DesMinDP).

For zone groups with demand control ventilation:

Reduce supply fan speed until absolute minimum outside air is introduced (60% of design minimum when not scheduled).

Record the pressure across the damper as the absolute minimum pressure setpoint (AbsMinDP)

Differential Pressure Set Point:

For units without demand control ventilation, MinDPsp = DesMinDP.

For units using demand control ventilation logic, MinDPsp is reset between AbsMinDP and DesMinDP based on zone ventilation demand.

See "Generic Ventilation Zones" for outside air requirements and resets.

Differential Pressure PID:

The loop is enabled when the fan is proven ON and the unit is in occupied mode and disabled otherwise.

A differential pressure sensor is located across the minimum outside air damper.

The pressure sensor provides an input to a control loop, the loop set point is the MinDPsp calculated above, and the loop output is used to modulate the return damper.

**Minimum Outside Air Damper Control:**

A modulating damper is used to allow for slow introduction of ventilation air. When the supply fan is proved ON and the schedule switches to occupied, the damper is commanded from 0% to 100% over a period of 20 minutes to allow the temperature control loops enough time to react. If the fan is OFF or the schedules is not occupied the damper is commanded closed.

**Return Air Damper Control**

The damper modulates to maintain ventilation pressure when the supply fan is proved ON and the unit is in occupied mode, and it is commanded fully open otherwise.

The output of the ventilation pressure loop is mapped to control the damper from 0% to MaxRA-P as required to maintain pressure setpoint.

MaxRA-P is linearly reset from 100% when the economizer damper is closed to 0% when the economizer damper is fully open.

**Building Static Pressure Control:**

Building static pressure shall be time averaged with a sliding 5-minute window and 15 second sampling rate (to dampen fluctuations). The averaged value shall be that displayed and used for control.

A control loop maintains the building pressure at a set point of 0.03 in. of water with an output ranging from 0% to 100%.

The loop is enabled when building pressure rises above 0.05 in. of water.

The loop is disabled and output set to zero when building pressure drops below 0.01 in. of water.

The loop output is mapped to all the relief fans and relief dampers serving a common/shared volume.

**Chilled Water Pressure Reset Request:**

If the supply air temperature exceeds the supply air temperature set point by 5°F for 2 minutes, send 3 requests.

Else if the supply air temperature exceeds the supply air temperature set point by 3°F for 2 minutes, send 2 requests.

Else if the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 85%.

Else if the CHW valve position is less than 95%, send 0 requests.

**Call for Cooling:**

Send the chiller plant that serves the system a chiller plant request as follows:

If the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 10%.

Else if the CHW valve position is less than 95%, send 0 requests.

The chiller plant will start when there is at least one request for 5 minutes and stop when there are no requests for 5 minutes, after a minimum run-time has elapsed.

Actuation of the chilled water valve resulting from a low limit / freeze stat safety shall not produce a call for cooling request. However, this condition shall result in the enabling of a chilled water system pump to circulate water. See the chilled water plant pump control sequence.

**Hot Water Pressure Reset Request:**

If the supply air temperature is 30°F less than set point for 5 minutes, send 3 requests.

Else if the supply air temperature is 15°F less than set point for 5 minutes, send 2 requests.

Else if HW valve position is greater than 95%, send 1 request until the HW valve position is less than 85%.

Else if the HW valve position is less than 95%, send 0 requests.

**Call for Heating:**

Send the heating hot-water plant that serves the AHU a heating hot-water plant request as follows:

If the HW valve position is greater than 95%, send 1 request until the HW valve position is less than 10%.

Else if the HW valve position is less than 95%, send 0 requests.

The hot water plant will start when there is at least one request for 5 minutes and stop when there are no requests for 5 minutes, after a minimum run-time has elapsed.

**Alarms:**

Fan/Pump/Wheel Alarm:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

<u>Filter Pressure:</u>

Differential pressure drop exceeds alarm limit: Level 4.

The alarm limit shall vary with total airflow (if available; use fan speed if total airflow is not known) as follows:

DPx = DP100*(x)^1.4

Where DP100 is the high-limit pressure drop at design airflow (determine limit from filter manufacturer) and DPx is the high limit at the current airflow rate x (expressed as a fraction). For instance, the set point at 50% of design airflow would be (0.5)^1.4, or 38% of the design high-limit pressure drop.

<u>Low Mixed Air Temperature:</u>

Air temperature entering the cooling coil is below 50°F: Level 2.

<u>High building pressure</u>

Pressure is more than 0.10 in. of water: Level 3.

<u>Low building pressure</u>

Pressure is less than 0.0 in. of water (i.e., negative): Level 4.

<u>Airflow sensor malfunction:</u>

Ventilation flow is 20% greater or 20% lower than setpoint for 60 minutes, or the fan has been OFF for 10 minutes and airflow sensor reading is above 10% of the unit's maximum airflow, generate a Level 4 alarm.

<u>CO2 Sensor Malfunction:</u>

If the zone CO2 is above 1900ppm or below 200ppm for 24hrs, generate a Level 4 alarm.

## SECTION 25 95 07 - DOMESTIC HOT WATER SYSTEM - ART ANNEX

The domestic water systems are fitted with a recirculating pump and three temperature sensors measuring water heater temperature, return water temperature, and supply water temperature leaving the mixing valve.

### <u>Pump Control:</u>

The domestic hot water pump is commanded on when any schedule is occupied and off when all schedules are unoccupied. The pump is started ahead of schedule such that hot water is available when the schedule goes occupied.

When the pump is first commanded on, the controller will measure the amount of time that it takes for the return temperature to be within 2°F of the supply temperature and record this value for the next cycle. The next time the schedule goes occupied, the pump will be enabled ahead of schedule based on the previously recorded time value.

When multiple pumps serve the same system, pumps rotate to render equal runtime.

### <u>Pump Alarm:</u>

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2
Commanded OFF, status ON: Level 4

## SECTION 25 95 08 - STUDENT LOUNGE

**Overview:**

The student lounge is conditioned and ventilated via a pair of blower coil units located in the ceiling space of the lounge. BCU-1 is the dedicated ventilating unit and the system contains OA damper, filters, electric preheat coil, unit filters, chilled water coil, fan and duct mounted electric heating coil. The unit delivers consistent dehumidified ventilation air to the student lounge. It is provided with a hydronic reheat coil in the unit in preparation for future changeover to a 4-pipe system.

BCU-2 is a sensible temperature control unit on the 2-pipe system. It contains filters, hydronic changeover coil, reheat coil in preparation for future upgrade, and supply fan. It does not supply ventilation to the student lounge

**Zone Occupancy:**

Lounge Schedule:

Mon-Fri: 7am-10pm

Sat-Sun: 8am-8pm

**Zone Temperature Setpoint:**

See "Generic Thermal Zones" for set points.

**Optimum Start:**

Conditioning of the zone shall start prior to occupancy such that the zones are at setpoint when the schedule switches to occupied.

**Supply Fan Control:**

Fan Enable:

The supply fan shall run whenever the unit is in any mode other than unoccupied mode.

Fan Speed Control:

Provide a ramp function to prevent changes in fan speed of more than 10% per minute.

Minimum and maximum fan speeds shall be as follows:

MinSpeed: The speed that provides supply airflow equal to design outside air

MaxHeatSpeed: The speed that provides supply airflow equal to the design heating airflow scheduled on plans. If no heating airflow is provided on plans, default to half of the maximum cooling speed.

MaxCoolSpeed: The speed that provides supply airflow equal to the design cooling airflow scheduled on plans.

Heating:

For a heating-loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

For a heating-loop signal of 50% to 0%, fan speed set point is MinSpeed.

Deadband:

In deadband, fan speed set point is MinSpeed.

Cooling:

For a cooling-loop signal of 0% to 50%, fan speed is MinSpeed

For a cooling-loop signal of 50% to 100%, fan speed is reset from MinSpeed to MaxCoolSpeed.

**Supply Air Temperature Reset:**

Minimum and maximum supply air temperature set points shall be as follows:

Cool_SAT, lowest cooling supply air temperature set point, typically 55°F

Heat_SAT, highest heating supply air temperature set point, typically 20°F above the active heating set point.

The Deadband value of SAT-SP shall be the average of the zone heating set point and the zone cooling set point but shall be no lower than 68°F and no higher than 75°F.

Temperature Reset:

When the supply fan is proven ON, fan speed and supply air temperature set points are controlled using two PID loops, one for heating and one for cooling.

See "Generic Thermal Zones" for set points, loops, and control states.

Heating:

For a heating loop signal of 0% to 50%, SAT-SP is reset from the Deadband value to Heat_SAT

For a heating loop signal of 50% to 100%, SAT-SP is Heat_SAT and supply fan speed is reset from min to heating max.

Deadband:

In deadband, SAT-SP is the deadband value.

Cooling:

For a cooling loop signal of 0% to 50%, SAT-SP is reset from the deadband value to Cool_SAT

For a cooling loop signal of 50% to 100%, SAT-SP is Cool_SAT and supply fan speed is reset from min to cooling max.

**Supply Air Temperature Control:**

There are two separate control loops, one for cooling and one for heating, both loops use the same supply air temperature sensor and setpoint.

Heating SAT PID:

The loop is enabled when heating is enabled and disabled otherwise. The loop output modulates the reheat coil to maintain supply air temperature at set point.

Cooling SAT PID:

The loop is enabled when cooling is enabled and disabled otherwise. The loop output modulates the cooling coil to maintain supply air temperature setpoint.

**Ventilation Control:**

See "Generic Ventilation Zones" for setpoints.

Outside Air Damper Positions:

These damper positions shall be determined in conjunction with the balancing contractor.

DesPosMin. The outdoor air damper position required to provide DesOA when the supply fan is at MinSpeed.

DesPosMax. The outdoor air damper position required to provide DesOA when the supply fan is at MaxCoolSpeed.

Where:

DesOA is the scheduled design ventilation value.

At least once per minute while the zone is in occupied mode, the BAS shall calculate MinOA-P as a linear interpolation between DesPosMin and DesPosMax based on the current fan speed.

**Outside Air Damper Control:**

The damper modulates to maintain ventilation or for economizer when the unit is in occupied mode and the supply fan is proved ON and it is closed otherwise.

When the schedule switches to occupied, the damper is commanded from 0% to MinOA-P over a period of 20 minutes to allow the temperature loops enough time to react. After the schedule has been enabled for 20 minutes, the rate of change limit shall be inhibited.

When economizer is enabled, the damper is commanded from MinOA-P to MaxOA-P by the economizer sequence.

**Return Air Damper Control:**

The return air damper controls equal and opposite to the outside air damper.

**Dehumidification:**

When outside air temperature is humid, air temperature leaving the cooling coil is maintained at 55°F for dehumidification.

When the fan is proved ON and the unit is operating in occupied mode and the outside air dewpoint is above 56°F, the dehumidification loop will be enabled. If outside air dewpoint is below 55°F or the unit is operating in a mode other than occupied, the loop will be disabled.

An averaging temperature sensor between the cooling and reheat coils provides an input to the loop, the loop setpoint is constant 55°F, and the loop output is mapped to the cooling coil.

**Preheat Air Temperature Control:**

Preheat temperature is maintained at 55°F in order to prevent freezing of the coils downstream.

When the schedule goes occupied and unit starts introducing outside air, the preheat setpoint is temporarily increased to 85°F and it resets down to 55°F over a period of 20 minutes.

Preheat Temp PID:

The control loop is enabled when outside air temperature is below 45°F and disabled above 50°F.

An averaging sensor downstream of the preheat coil is used for control. The loop output is mapped to the preheat valve.

**Chilled Water Valve Control:**

When the supply fan is proved ON and outside air temperature is above 55°F, the valve modulates to maintain supply air temperature for zone temperature control, and cooling coil leaving air temperature for humidity control, whichever requires the most cooling.

If the fan status is OFF or the outside air temperature is below 54°F the valve is locked out.

**Reheat Control:**

The electric heater modulates to maintain supply air temperature when the fan is proved ON.

**Supply Fan Control:**

Fan Enable:

The supply fan shall run whenever the unit is in any mode other than unoccupied mode.

Fan Speed Control:

MinSpeed: 30% of max cooling speed unless otherwise specified on the drawings.

MaxHeatSpeed: The speed that provides supply airflow equal to the design heating airflow scheduled on plans. If no heating airflow is provided on plans, default to the speed which results in an air temperature rise of 20°F

MaxCoolSpeed: The speed that provides supply airflow equal to the design cooling airflow scheduled on plans.

Heating:

For a heating loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

For a heating loop signal of 50% to 0%, fan speed set point is MinSpeed.

Deadband:

In deadband, fan speed set point is MinSpeed.

Cooling:

For a cooling loop signal of 0% to 50%, fan speed is MinSpeed

For a cooling loop signal of 50% to 100%, fan speed is reset from MinSpeed to MaxCoolSpeed.

**Economizer Control:**

Lockout:

See "General" for high limits.

When economizer is enabled, MaxOA-P = 100%.

When economizer is disabled, set MaxOA-P equal to MinOA-P. See "Supply Air Temperature Control," and "Minimum Outdoor Air Control," for outdoor air damper minimum set point.

Mixed Air Temperature Setpoint:

The setpoint shall be calculated by subtracting fan heat and 1°F from the supply air temperature setpoint. Where fan heat is calculated by subtracting cooling coil leaving air temperature from discharge air temperature.

MAT-SP = SAT-SP – (SA-T – CC-T) – 1°F

Economizer PID:

The loop is enabled when economizer is enabled, the supply fan is proved ON, and the unit is not heating.

Mixed air temperature shall be controlled to setpoint using a control loop whose output is mapped to command the outside air damper from MinOA-P to MaxOA-P.

**Multiple Units Serving One Room:**

When multiple fan coil units serve a common room, one unit is setup as the leader and performs the Zone Temperature Control calculations. The rest of the units are setup as followers, using the cooling and heating loop outputs from the leader unit.

When multiple zone temperature sensors are installed, the average of all sensors is used for control.

**Alarms:**

Fan Alarm:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

Leaking Valve:

If the cooling valve position is 0% for 15 minutes, DAT is below room temperature by 10°F. and the fan serving the zone is proven ON, generate a Level 4 alarm.

## SECTION 25 95 09 - SCENE SHOP

**Overview**

The scene shop is conditioned by a four pipe blower coil unit with cooling coil, reheat coil and fan. The blower coil unit also controls an outside air damper, steam preheat coil with face and bypass damper. Filters are located upstream of the steam preheat coil. The unit modulates airflow and supply air temperature to maintain consistent dehumidification setpoints, consistent space temperature, and provide makeup air for general scene shop exhaust and dust collector exhaust.

User input manual start/stop buttons enable and disable the dust collector as required. A general exhaust fan GEF-1 provides minimum code required exhaust and modulates speed to relieve excess OA air from BCU-3 during peak heating and cooling times.

**In normal occupied hours, the general exhaust fan maintains a speed determined by the balancer to exhaust 1150 cfm. When the dust collector is on, GEF-1 is disabled and BCU-3 is commanded to a balanced speed that delivers 1500 cfm OA.**

**<u>Supply Fan Control:</u>**

Fan Enable:
The supply fan shall run at all times.
Fan Speed Control:
Provide a ramp function to prevent changes in fan speed of more than 10% per minute.
The balancer shall determine and record the fan speed required to deliver the following flowrates:
Minimum and maximum fan speeds shall be as follows:
Minimum Unoccupied setpoint: 700 cfm
Minimum Occupied setpoint: 1150 cfm
Minimum Dust collector makeup air setpoint: 1500 cfm.
Maximum cooling setpoint: 2200 cfm.

The balancer shall use these speed values to determine the fan speed for the general exhaust fan GEF-1.

Heating:
For a heating-loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.
For a heating-loop signal of 50% to 0%, fan speed set point is MinSpeed.
Deadband:
In deadband, fan speed set point is MinSpeed.

Cooling:

For a cooling-loop signal of 0% to 50%, fan speed is MinSpeed

For a cooling-loop signal of 50% to 100%, fan speed is reset from MinSpeed to MaxCoolSpeed.

**Supply Air Temperature Reset:**

Minimum and maximum supply air temperature set points shall be as follows:

Cool_SAT, lowest cooling supply air temperature set point, typically 55°F

Heat_SAT, highest heating supply air temperature set point, typically 20°F above the active heating set point.

The Deadband value of SAT-SP shall be the average of the zone heating set point and the zone cooling set point but shall be no lower than 68°F and no higher than 75°F.

Temperature Reset:

When the supply fan is proven ON, fan speed and supply air temperature set points are controlled using two PID loops, one for heating and one for cooling.

See "Generic Thermal Zones" for set points, loops, and control states.

Heating:

For a heating loop signal of 0% to 50%, SAT-SP is reset from the Deadband value to Heat_SAT

For a heating loop signal of 50% to 100%, SAT-SP is Heat_SAT and supply fan speed is reset from min to heating max.

Deadband:

In deadband, SAT-SP is the deadband value.

Cooling:

For a cooling loop signal of 0% to 50%, SAT-SP is reset from the deadband value to Cool_SAT

For a cooling loop signal of 50% to 100%, SAT-SP is Cool_SAT and supply fan speed is reset from min to cooling max.

**Supply Air Temperature Control:**

There are two separate control loops, one for cooling and one for heating, both loops use the same supply air temperature sensor and setpoint.

Heating SAT PID:

The loop is enabled when heating is enabled and disabled otherwise. The loop output modulates the reheat coil to maintain supply air temperature at set point.

Cooling SAT PID:

The loop is enabled when cooling is enabled and disabled otherwise. The loop output modulates the cooling coil to maintain supply air temperature setpoint.

**Preheat Air Temperature Control:**

Preheat coil temperature is reset based on outside air temperature. When OAT is less than 40°F, the reheat coil is locked out and the preheat coil modulates to maintain unit discharge air temperature. When OAT is between 40°F and 50°F, PHC DAT is set to 55F.

When the schedule goes occupied and the unit starts introducing outside air, the preheat setpoint is temporarily increased to 85°F and it resets down to 55°F over a period of 20 minutes.

Preheat Temp PID:

The control loop is enabled when outside air temperature is below 45°F and disabled above 50°F.

An averaging sensor downstream of the preheat coil is used for control. The loop output is mapped to the preheat valve control loop.

**Preheat Valve Control:**

The steam control valves SCV-1 and SCV-2 are sized in parallel for 1/3 and 2/3 of the steam flow respectively. As the call for heat from the PID loop modulates from 0% to 33%, SCV-1 modulate from 0% open to 100% open. As the call for heat from the PID modulates from 33% to 100%, SCV-2 modulates from 0% open to 100% open.

When outside air is above 50°F the valve is locked closed.

**Preheat Coil Bypass Damper**

If the preheat coil call for heat is below 10% and the 1/3 flow control valve SCV-1 is open less than 5%, the steam control valve shall be held at a minimum position of 5% open and the bypass damper shall modulate open to cool the OA back to setpoint temperature.

**Dehumidification:**

When outside air temperature is humid, dewpoint temperature leaving the unit is maintained at 55°F for dehumidification. This dewpoint temperature is calculated from the discharge air temperature and humidity sensors in the discharge air ductwork.

When the fan is proved ON and the outside air dewpoint is above 56°F, the dehumidification loop will be enabled. If outside air dewpoint is below 55°F, the loop will be disabled.

An averaging temperature sensor between the cooling and reheat coils provides an input to the loop, the loop setpoint is constant 55°F, and the loop output is mapped to the cooling coil.

**Chilled Water Valve Control:**

When the supply fan is proved ON and outside air temperature is above 55°F, the valve modulates to maintain supply air temperature for zone temperature control or cooling coil leaving air dewpoint for humidity control, whichever requires the most cooling.

If the fan status is OFF or the outside air temperature is below 54°F the valve is locked out.

**Reheat Valve Control:**

The heating water reheat coil is only used for tempering supply air in the shoulder and summer seasons. When OAT is less than 40F, the reheat valve is locked out and the steam heating coil control valve modulates to maintain discharge air temperature setpoint.

The valve modulates to maintain supply air temperature when the fan is proved ON and when OAT is greater than 40F.

**Ventilation Control:**

Outside Air Damper Positions:

The OA damper is a two position isolation damper. Ventilation airflow is equivalent to fan airflow as the unit is 100% OA. The balancer shall determine fan speed setpoints for the following conditions:

Minimum Unoccupied setpoint: 700 cfm

Minimum Occupied setpoint: 1150 cfm

Minimum Dust collector makeup air setpoint: 1500 cfm.

When the unit is off, the ventilation damper shall be closed.

## SECTION 25 95 10 - COOLING PLANT SYSTEM - CRAIG HALL

**Overview:**

**Cooling capacity is provided for the building via a district chilled water loop and booster pump located in the basement mechanical room of Craig Hall. At low load, the district water pumps circulate chilled water through the building to meet cooling needs. As chilled water valves open 100% and cooling demands are no longer being met, the Chilled Water Plant shall be enabled and variable speed chilled water booster pump is enabled to provide additional flow to the cooling coils of Craig Hall.**

**Chilled Water Plant Reset**

Chilled water pump differential pressure setpoint CHW-DPsp shall be reset based on the current value of the logic variable called “CHW Plant Reset” as described subsequently.

The plant sums of all chilled water pressure requests from the associated air handlers and uses the sum as an input to a PID loop. The loop setpoint is 1, and the loop output commands the CHW Plant Reset from 0% to 100%.

As the CHW Plant Reset goes from 0% to 100%, reset the CHW-DPsp from CHW-DPmin to CHW-DPmax.

**Chilled Water Pressure Control:**

Remote secondary loop DP shall be maintained at a setpoint of CHW-DPsp determined by the reset scheme described herein. CHW-DPsp shall be maintained by a reverse acting PID loop running in the controller to which the remote sensor is wired; the loop output shall be mapped to reset DP setpoint for the local secondary loop DP from LocalDPmin at 0% loop output to LocalDPmax at 100% loop output.

LocalDPmin shall be set to 5psi and be made adjustable by the operator.

LocalDPmax shall be determined by the balancer such that all devices can achieve design flow.

Plant pressure is controlled by a reverse acting PID loop, the loop setpoint is calculated using the output of the remote pressure loop, and the loop output is mapped to control secondary pump speed.

Where multiple remote DP sensors exist, a PID loop shall run for each sensor. The DP setpoint for the local DP sensor shall be the highest DP setpoint output from each of those remote loops.

**Chilled Water Pump Control:**

Pump Enable:

Enable the pump when plant is enabled or there is a freezestat event.

Pump Speed Control:

Once enabled, the pump shall control to the speed necessary to maintain local differential pressure. The differential pressure loop output is mapped to command the pumps from 30% to 100% speed.

If a freezestat alarm is received when the plant is disabled, the pump is commanded to 30% speed.

Pumps' acceleration VFD settings shall be set to 90 seconds.

Pump Failure:

If an online pump fails, a level 2 alarm shall be generated.

## SECTION 25 95 11 – EXHAUST AND TRANSFER FANS

### Toilet and General Exhaust

Constant volume exhaust fans are controlled by the BAS based on their area of service zone group schedule.

See "Zone Groups" for scheduled hours.

### Scene Shop General Exhaust

When enabled, the scene shop general exhaust fan maintains a speed set by the balancer to maintain the following setpoints:

Minimum Unoccupied setpoint: 700 cfm

Minimum Occupied setpoint: 1150 cfm

Minimum Dust collector makeup air setpoint: 1500 cfm.

Maximum cooling setpoint relief from BCU-3. BCU-3 shall have its supply fan flowrate calculated from the fan speed and balanced table of values and GEF-1 fan speed shall be provided a speed command to match the exhaust and supply flowrates.

### Paint Booth Exhaust

The paint booth exhaust fan is a constant volume fan enabled by the user with a switch.

### DTSM Classroom Exhaust

Paint booth exhaust fan and 3D printer exhaust fan are manually operated using toggle switches and are monitored by the BAS.

### DTSM Classroom Paint Booth Transfer Fan

Constant volume transfer fan that is activated when the paint booth fan is manually turned on. The transfer fan will provide ducted transfer air from the level-2 plenum space to the DTSM Classroom as makeup air for the paint booth.

### Alarms:

BAS Controlled Fans:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

Manually Controlled Fans:

The fan has been proved ON for more than 24 hours: Level 4

## SECTION 25 95 12 - CONSTANT VOLUME FAN COIL UNITS

**Overview:**

The fan coil unit maintains room setpoint using a deadband, two different setpoint are used for heating and cooling.

**Zone Temperature Setpoint:**

See "Generic Thermal Zones" for set points.

**Optimum Start:**

Conditioning of the zone shall start prior to occupancy such that the zones are at setpoint when the schedule switches to occupied.
See "Zone Groups" for zone cooldown and warmup.

**Zone Temperature Control:**

Zone Temperature is controlled by modulating the cooling and heating valves.
See "Generic Thermal Zones" for control loops.
Zone Cooling:
When the zone state is cooling, the cooling loop output shall be mapped to control the cooling valve from 0% to 100%.
Heating valve is OFF.
Zone Heating:

When the zone state is heating, the heating loop shall maintain space temperature at the heating set point by modulating the heating valve.

Cooling valve is OFF.

From 0% to 50%, the heating-loop output shall reset the discharge temperature set point from the current

Zone Deadband:

When the zone state is deadband, both valves are closed.

**Fan Control:**

The fan runs at constant speed when the unit is operating in any mode other than unoccupied.

**Alarms:**

Fan Alarm:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

Leaking Valve:

If the valve position is 0% for 15 minutes, DAT differs from room temperature by 10°F, and the fan

serving the zone is proven ON, generate a Level 4 alarm.

## SECTION 25 95 13 - VARIABLE VOLUME FAN COIL UNIT

**Overview:**

The fan coil unit maintains room setpoint using a deadband, two different setpoint are used for heating and cooling. When a room humidity sensor is available, the unit also maintains zone humidity by opening the cooling valve overriding the temperature sequence.

Discharge air temperature and supply fan speed are reset based on zone demand.

The unit is provided with a variable speed fan, modulating heating and cooling valves, a discharge temperature sensor, a ceiling mounted occupancy sensor (when available by div26, a zone temperature sensor, and filters.

**Zone Occupancy:**

The zone is part of a zone group, see “Zone Groups” for operating modes.

When zone occupancy sensors are available:

The zone is allowed to independently go into Standby mode if the zone group is occupied and the sensor does not detect motion for 15 minutes.

**Zone Temperature Setpoint:**

See “Generic Thermal Zones” for set points.

**Optimum Start:**

Conditioning of the zone shall start prior to occupancy such that the zones are at setpoint when the schedule switches to occupied.

See “Zone Groups” for zone cooldown and warmup.

**Supply Air Temperature Reset:**

Minimum and maximum supply air temperature set points shall be as follows:

Cool_SAT, lowest cooling supply air temperature set point, typically 55°F

Heat_SAT, highest heating supply air temperature set, typically 20°F above the active heating set point.

The Deadband value of SAT-SP shall be the average of the zone heating set point and the zone cooling set point but shall be no lower than 68°F and no higher than 75°F.

Temperature Reset:

When the supply fan is proven ON, fan speed and supply air temperature set points are controlled using two PID loops, one for heating and one for cooling.

See “Generic Thermal Zones” for set points, loops, and control states.

Heating:

For a heating loop signal of 0% to 50%, SAT-SP is reset from the Deadband value to Heat_SAT

For a heating loop signal of 50% to 100%, SAT-SP is Heat_SAT and supply fan speed is reset from min to heating max.

Deadband:

In deadband, SAT-SP is the deadband value.

Cooling:

For a cooling loop signal of 0% to 50%, SAT-SP is reset from the deadband value to Cool_SAT

For a cooling loop signal of 50% to 100%, SAT-SP is Cool_SAT and supply fan speed is reset from min to cooling max.

**Supply Air Temperature Control:**

There are two separate control loops, one for cooling and one for heating, both loops use the same supply air temperature sensor and setpoint.

Heating SAT PID:

The loop is enabled when heating is enabled and disabled otherwise. The loop output modulates the reheat coil to maintain supply air temperature at set point.

Cooling SAT PID:

The loop is enabled when cooling is enabled and disabled otherwise. The loop output modulates the cooling coil to maintain supply air temperature setpoint.

**Chilled Water Valve Control:**

When the supply fan is proved ON the valve modulates to maintain supply air temperature for zone temperature control.

If the fan status is OFF or heating is ON the valve is locked out.

**Heating Water Valve Control:**

The valve modulates to maintain supply air temperature when the fan is proved ON.

If the fan status is OFF or cooling is ON the valve is locked out.

**Supply Fan Control:**

Fan Enable:

The supply fan shall run whenever the unit is in any mode other than unoccupied mode.

Fan Speed Control:

MinSpeed: 30% of max cooling speed unless otherwise specified on the drawings.

MaxHeatSpeed: The speed that provides supply airflow equal to the design heating airflow scheduled on plans. If no heating airflow is provided on plans, default to the speed which results in an air temperature rise of 20°F

MaxCoolSpeed: The speed that provides supply airflow equal to the design cooling airflow scheduled on plans.

Heating:

For a heating loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.

For a heating loop signal of 50% to 0%, fan speed set point is MinSpeed.

Deadband:

In deadband, fan speed set point is MinSpeed.

Cooling:

For a cooling loop signal of 0% to 50%, fan speed is MinSpeed

For a cooling loop signal of 50% to 100%, fan speed is reset from MinSpeed to MaxCoolSpeed.

**Heating Hot Water Plant Pressure Request:**

If the valve position is greater than 95%, send 1 request until the valve position is less than 85%.

Else if the valve position is less than 95%, send 0 requests.

Importance Multiplier for pressure requests shall be limited to 1 or less, if set greater than 1 the heating loop will remain at max pressure.

**Multiple Units Serving One Room:**

When multiple fan coil units serve a common room, one unit is setup as the leader and performs the Zone Temperature Control calculations. The rest of the units are setup as followers, using the cooling and heating loop outputs from the leader unit.

When multiple zone temperature sensors are installed, the average of all sensors is used for control.

**Alarms:**

Fan Alarm:

Indicated by the status being different from the command for a period of 15 seconds.

Commanded ON, status OFF: Level 2

Commanded OFF, status ON: Level 4

Leaking Valve:

If the heating valve position is 0% for 15 minutes, DAT is above room temperature by 10°F, and the fan

serving the zone is proven ON, generate a Level 4 alarm.

If the cooling valve position is 0% for 15 minutes, DAT is below room temperature by 10°F. and the fan serving the zone is proven ON, generate a Level 4 alarm.

## SECTION 25 95 14 - CABINET UNIT HEATERS

**Overview:**

Cabinet unit heaters serving stairs, corridors, and mechanical rooms are provided with vandal resistant box mounted zone temperature sensors with flush stainless steel wall plate.

The unit controller operates the constant volume fan and two-position heating valve to maintain a constant heating setpoint.

**Zone Temperature Control:**

The zone temperature setpoint shall be constant 65°F, adjustable by the operator.

When the zone temperature drops 1°F below setpoint, the valve will open and the fan will start.

Once the zone temperature rises 1°F above setpoint, the valve closes and the fan stops.

**Alarms:**

Generate a Level 3 alarm if zone temperature drops below 55°F

# SECTION 26 05 13 – MEDIUM VOLTAGE CABLE, TERMINATIONS, AND SPLICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Cables
   2. Terminations
   3. Splices and splice kits
   4. Separable insulated connectors

### 1.2 ACTION SUBMITTALS

A. Product Data

B. Samples: 16” samples for each type of medium voltage cable specified including jacket markings.

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers installation instructions

B. Installer certifications

C. Factory Cable Test Results for each cable provided.

D. Coordination Drawings: Show location of each cable, splice and termination.

### 1.4 CLOSEOUT SUBMITTALS

A. Post-installation Hi-pot test results

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Cables

1. Prysmian
2. Southwire
3. Okonite
4. Superior Essex
5. General Cable Co.

B. Splices and Terminations
1. 3M
2. Eaton Cooper Power Systems
3. Elastimold
4. Hubbell
5. Raychem

C. Separable Insulated Connectors
1. 3M
2. Eaton Cooper Power Systems
3. Elastimold
4. Hubbell
5. Raychem

## 2.3 CABLES

A. Shielded cable shall be Type MV 105 rated 15KV 105°C with a single compact Class B stranded copper conductor. The construction shall include an extruded conductor shield, EPR insulation rated 133%, a wrapped helically overlapped copper tape shield and a PVC jacket. Cable shall be furnished in sizes as shown on the drawings.

## 2.4 SPLICES, TERMINATIONS, SEPARABLE INSULATED CONNECTORS

A. 5/15/35KV splices for shielded single conductor cables shall be 3M Series 5500. A 3M C1 series connector must be used for conductor sizes #2 – 250MCM. 5/15/35KV terminations shall be 3M Series 7600. Connectors for splices and lugs for terminations shall be compatible with the cable and terminal, compression type rated for 5000/15000/35000 volts and installed per manufacturer's requirements.

B. 5KV splices for unshielded single conductor cables shall be 3M Series 5740. A 3M C1 series connector must be used for conductor sizes #2 – 250MCM. 5KV terminations shall be 3M Series 5610A. Connectors for splices and lugs for terminations shall be compatible with the cable and terminal, compression type rated for 5000 volts and installed per manufacturer's requirements.

C. Provide 200A load break elbows as indicated on the drawings for cable terminations. Elbows shall be equipped with test ports.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Furnish and install a 5KV distribution system, including manholes, conduits, cables, splices, terminations, concrete ductbanks, trenching and backfill as indicated on the drawings.

B. The minimum cable bending radius required by the NEC and the cable manufacturer shall be maintained. In cases where the two differ, a minimum of 12 times the outside cable diameter shall be used, or the larger bending radius shall be used, whichever is larger. Cable installation into or out of manholes shall be done using a Heavy-Duty Quadrant Block, similar to a Condux International Catalog No. 08539100 (six 4" sheaves on a 24" radius). A minimum bending radius of 16 inches shall be maintained.
   1. Bending cables to less than the minimum radius shall be a reason for not accepting the cable.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

   1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
   3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
   4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. All junction and pull boxes shall be sized in accordance with National Electric Code requirements.

E. Medium voltage splices and terminations shall be installed where indicated on the drawings or as approved by the Owner's Representative.

F. Cable splices shall be installed per manufacturer's recommendations including proper arrangement and preparation. Manufacturer should be contacted for any necessary installation restrictions and training.

G. Ground shields of shielded cables at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connection fittings, and hardware.

### 3.2 FIELD QUALITY CONTROL

A. Test the insulation values of all cables, terminations, and splices using a D.C. High Potential Test in accordance with ICEA S-68-516/NEMA WC-8. A controlled voltage source shall be used between the test equipment and power source. Testing shall reach a voltage of 25/65/124kV (5/15/35kV operating) and be held there for 15 minutes. Engineer or Owner's Representative shall be present to witness all tests. Submit a record of test results and plotted curves.

B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

**END OF SECTION 26 05 13**

# SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Copper building wire rated 600V or less
   2. Aluminum building wire rated 600V or less
   3. Type MC metal-clad cable rated 600V or less

B. Reference Sections:
   1. Division 26 Section "Identification for Electrical Systems"
   2. Division 27 Section “Communications Optical Fiber Backbone Cabling”
   3. Division 27 Section “Communications Copper Horizontal Cabling Systems”
   4. Division 27 Section “Communications Coaxial Horizontal Cabling Systems”

### 1.2 ACTION SUBMITTALS

A. Product data.

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required.

### 1.4 CLOSEOUT SUBMITTALS

A. Not required.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Comply with NFPA 70.

### 2.2 CONDUCTORS AND CABLES

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

1. Southwire Company
2. Encore Wiring
3. Nexans
4. United Copper Industries

B. Copper conductors and insulation shall comply with NEMA WC 70.

C. Acceptable multi-conductor cable types shall comply with NEMA WC 70:
   1. Type MC, metal clad cable, with ground wire

2.3 CONNECTORS AND SPLICES
   1. Available manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AFC Cable Systems, Inc.
      b. Hubbell Power Systems, Inc.
      c. O-Z/Gedney; EGS Electrical Group LLC
      d. 3M, Electrical Products Division
      e. Tyco Electronics Corp.
   2. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.4 PROVISIONS FOR WIRING:

A. Wire and cable of the sizes and types shown on the plans and/or hereinafter specified shall be furnished and installed by the Contractor.

B. All wire and cable shall be new soft drawn copper and shall conform to all the latest requirements of the National Electrical Code IPCEA, and meet the specifications of the ASTM.

2.5 CONTROL CONDUCTORS: Control circuit wiring shall be No. 12 AWG or smaller stranded wire. Stranded control wire shall be provided with crimp type spade terminators. Control circuit wiring shall be color-coded or numbered using an identical number on both ends of the conductor.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATION

A. No wire less than No. 12AWG shall be used except for control circuits or low voltage wiring.

B. Feeders: Copper solid for No. 10AWG and smaller; stranded for No. 8AWG and larger

C. Branch Circuits: Copper, stranded

D. Voltage Drop: Branch circuits shall be sized for maximum voltage drop of 3 percent per ASHRAE Standard 90.1. The following are minimum allowable conductor sizes based on conductor length.

Circuit length is measured as from the panelboard to the furthest device on the circuit. The phase and neutral conductors shall be sized as indicated for the entire length of the circuit unless a larger size is noted on the drawings.

1. 20A Branch Circuit Homeruns shall be sized as follows:
   a. 120V:
      1) 0 – 95 feet shall be #12AWG wire minimum
      2) 96 – 150 feet shall be #10AWG wire minimum
      3) 151 – 235 feet shall be #8AWG wire minimum
      4) 236 – 380 feet shall be #6 AWG wire minimum
   b. 277V:
      1) 0 – 200 feet shall be #12AWG wire minimum
      2) 201 – 350 feet shall be #10AWG wire minimum
      3) 351 – 550 feet shall be #8AWG wire minimum

E. Where conductors are upsized to account for deratings or voltage drop and are too large for the termination lugs, provide reducer pins equivalent to Burndy AYP or AYPO (offset pin). Reducer pins shall be compression type, dual rated for aluminum/copper conductors, and include an insulating cover.

## 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS

A. All conductors shall have insulation rated for 600V and 90°C

B. Underground Feeders: Type XHHW, single conductors in raceway unless shown or specified to be otherwise.

C. Feeders: Type THHN & THWN-2, single conductors in raceway unless shown or specified to be otherwise.

D. Branch Circuits: Type THHN & THWN-2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh and strain relief devices to suit application.

F. Class 1 Control Circuits: Type THHN-THWN-2, in raceway.

G. Class 2 Control Circuits: Type THHN-THWN-2, in raceway.

## 3.3 INSTALLATION

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

F. A single raceway shall be limited to a maximum of six current carrying conductors.

G. All 120V and 277V single phase circuits require a dedicated neutral conductor. The neutral conductor shall be numbered and identified with associated phase conductor at the panelboard as well as all junction boxes.

H. Where circuit runs are combined, upsize conduit and conductors to accommodate for conduit fill and conductor derating respectively.

I. Metal Clad (MC) Cable:
1. Permitted for wiring the final portion of light fixture branch circuits only. Fixture whips shall be limited to 6 feet maximum. The MC cable may be supported by the light fixture bracing wires but shall not be supported by the ceiling grid support wires.
2. Shall not be installed where exposed.

## 3.4 CONNECTIONS

A. 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.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

## 3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors for compliance with requirements.

a. Megger test for insulation integrity.
b. Test all branch circuit wiring for leakage current requirements for NFPA 99 for isolation panelboard.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

   a. Follow-up infrared scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of infrared scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

**END OF SECTION 26 05 19**

# SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connector.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" specifies seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.
4. Section 270528 "Pathways for Communications Systems" specifies additional requirements for grounding and bonding of communications raceways, boxes, and cable trays.
5. Section 271100 "Communications Equipment Room Fittings" specifies additional requirements for grounding and bonding of communications equipment.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding of Electrical Power" Article, including the following:

1. Grounding electrode access enclosures.
2. Grounding electrodes.

C. Field quality-control reports.

## 1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:

   a. Photographs of transformer grounding.

# PART 2 - PRODUCTS

## 2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Referenced Standards: Complying with one or more of the following:

   a. Soft or Annealed Copper Wire: ASTM B3.
   b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
   c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
   d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

## 2.2 CONNECTORS:

A. A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure (clamp) type with at least two bolts.

C. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Pressure Connectors: High-conductivity-plated units.

E. Bolted Clamps: Heavy-duty units listed for the application.

F. Exothermic Welded Connections: Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

G. Compression Connectors: Irreversible compression connectors must be factory filled with oxide inhibitor and fully crimped with a 14-ton or larger hydraulic tool so that index number is embossed on the connector. May be used above or below grade.

H. Lightning Protection Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lighting Protection Components," or UL 467.

## 2.3 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding devices that serve as common connection for multiple grounding and bonding conductors.

B. Predrilled rectangular bars of annealed copper, 1/4-inch by 6 inches in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

## 2.4 GROUNDING ELECTRODE ENCLOSURES

A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.

B. Ground Rods: Copper-clad steel.
   1. Size: 3/4 inch diameter by 10 feet length.

C. Test Wells: Provide handholes as required.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

## 3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:

   1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
   2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.

3. Underground Grounding Conductors: Install bare copper conductor, 4/0 AWG minimum.

B. Grounding and Bonding Connectors:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, telecommunication rooms, in rooms housing service equipment, and elsewhere as indicated on Drawings.

3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

A. Comply with Section 270528 "Pathways for Communications Systems".

3.4 INSTALLATION OF GROUNDING AND BONDING

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Grounding and Bonding Conductors:

a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
b. Underground Grounding Conductors:

1) Bury at least 30 inch (750 mm) below grade.
2) Duct-Bank Grounding Conductor: Bury 12 inch (300 mm) above duct bank when indicated as part of duct-bank installation.

2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
b. Make connections with clean, bare metal at points of contact.

c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.

g. Grounding and Bonding for Piping:

1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft (18 m) apart.

3. Grounding and Bonding Busbars:

a. Install busbar horizontally, on insulated spacers 2 inch (50 mm) minimum from wall, 6 inch (150 mm) above finished floor unless otherwise indicated.
b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.

4. Electrodes:

a. Ground Rods: Drive rods until tops are 2 inch (50 mm) below finished floor or final grade unless otherwise indicated.

1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2) Use exothermic welds for below-grade connections.

b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
c. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch (300 mm) deep, with cover.

1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

d. Concrete-Encased Electrode (Ufer Ground):

1) Fabricate in accordance with NFPA 70; use minimum of 20 ft (6 m) of bare copper conductor not smaller than 4 AWG.

a) If concrete foundation is less than 20 ft (6 m) long, coil excess conductor within base of foundation.
b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft (6.0 m) long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

5. Grounding at Service:

a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.

6. Grounding Underground Distribution System Components:

a. Duct-Bank Grounding Conductor: Bury 12 inch (300 mm) above duct bank when indicated as part of duct-bank installation.
b. Comply with IEEE C2 grounding requirements.
c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-

shrunk insulating sleeve from 2 inch (50 mm) above to 6 inch (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.

e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch (150 mm) from foundation.

7. Equipment Grounding and Bonding:

a. Install insulated equipment grounding conductors with feeders and branch circuits.

b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1) Feeders and branch circuits.
2) Lighting circuits.
3) Receptacle circuits.
4) Single-phase motor and appliance branch circuits.
5) Three-phase motor and appliance branch circuits.
6) Flexible raceway runs.
7) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

d. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.

e. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground fence and bond fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.5 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Field tests and inspections must be witnessed by Owner.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
    c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

C. Nonconforming Work:

1. Grounding system will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective components and retest.

D. Collect, assemble, and submit test and inspection reports.

1. Report measured ground resistances that exceed the following values:

    a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω
    b. Substations and Pad-Mounted Equipment: 5 Ω.
    c. Manhole Grounds: 10 Ω.

3.6 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

**END OF SECTION 260526**

# SECTION 26 05 33 – RACEWAY FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Electrical metallic tubing conduit (EMT)
2. Galvanized rigid steel conduit (GRS)
3. Rigid aluminum conduit
4. Polyvinyl chloride conduit (PVC)
5. Liquid-tight flexible metal conduit
6. Flexible metal conduit
7. High density polyethylene conduit (HDPE)
8. PVC coated galvanized rigid conduit
9. Surface raceway
10. Pre-wired raceway

### 1.2 ACTION SUBMITTALS

A. Product Data:
1. Surface mounted raceway
2. Pre-wired raceway

B. Shop Drawings:
1. Pre-wired raceway

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

### 1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. Product shall be UL approved.

C. Comply with NFPA 70.

D. Comply with ANSI C2.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Available manufacturers: Subject to compliance with requirements, provide product by one of the following:

1. AFC Cable Systems, Inc.
2. Alflex Inc., a unit of Southwire.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Republic Conduit, a unit of Tenaris.
7. Western Tube and Conduit Corporation.
8. Wheatland Tube Company.

B. Surface mounted and pre-wired raceway
1. Wiremold
2. Panduit
3. Hubbell
4. MonoSystems

### 2.2 ELECTRICAL METALLIC TUBE CONDUIT (EMT)

A. EMT conduit shall be installed for all work concealed in partitions or in concrete block walls and for all conduits run in ceiling plenums and exposed runs, except where noted otherwise. Aluminum EMT is not approved. EMT conduit shall not be used outdoors, in wet locations, in floor crawl spaces, or below 5’ AFF.

B. EMT couplings and connectors shall be steel insulated throat compression type.

### 2.3 GALVANIZED RIGID STEEL CONDUIT (GRS)

A. Galvanized rigid steel conduits shall be installed for all exposed outdoor conduit, and for all indoor medium voltage cable runs, and for entry into underground building walls and manholes.

B. All GRS couplings and threaded hubs shall have no less than five threads of the coupling engaged. Running threads shall not be used. All GRS conduits shall be reamed.

C. All GRS conduits shall have two locknuts and a bushing at each termination outlet box, junction box, etc., except where terminated in a threaded hub.

D. GRS conduit shall be installed where underground conduits and duct banks enter through building foundation, tunnel walls, and drilled holes in manhole walls. The heavy wall conduit shall enter through core drilled holes and the annular space between the conduit and wall sealed using

Thunderline Corp. “Link-Seal” Catalog No. 10-LS-300-C seals. This catalog number is for a 4 inch heavy wall steel conduit and requires a 6 inch I.D. core drilled hole. Refer to the manufacturer’s installation requirements prior to drilling holes and for other conduit sizes. Seals as manufactured by Innerlynx Model C and Flexicraft Type E are acceptable equivalents.

## 2.4 POLYVINYL CHLORIDE CONDUIT (PVC)

A. Conduits installed underground shall be schedule 40 PVC and a minimum size of ¾” trade size. PVC conduits may be installed in concrete floor slabs, and shall be a minimum of ¾” trade size. Rigid galvanized steel elbows shall be used for all stub-ups through or out of concrete slabs or through underground wall penetrations.

B. All PVC fittings shall be connected with PVC primer and glue.

## 2.5 LIQUID-TIGHT FLEXIBLE METAL CONDUIT

A. Liquid-tight flexible steel conduit (‘Sealtite’) shall be used in wet areas where flexible conduit connections are required and on all motorized equipment and motors in all locations.

B. Liquid-tight flexible metal conduit (‘Sealtite’) is not permitted for roof penetrations.

## 2.6 FLEXIBLE METAL CONDUIT

A. Flexible steel conduit (‘Greenfield’) shall be used where vibration isolation is required, including all transformers and uninterruptible power systems.

## 2.7 HIGH DENSITY POLYETHYLENE CONDUIT (HDPE)

A. Type HDPE Schedule 40 conduit may be used for site lighting conduits.

B. Type HDPE Schedule 40 to be used for all directional boring applications. Provide UL listed coupling fitting where transitioning from HDPE to PVC/GRC.

## 2.8 PVC COATED GALVANIZED RIGID STEEL CONDUIT

A. PVC coated galvanized rigid steel conduits shall be installed for all exposed outdoor conduit.

B. All PVC coated GRS couplings and threaded hubs shall have no less than five threads of the coupling engaged. Running threads shall not be used. All PVC coated GRS conduits shall be reamed.

C. All PVC coated GRS conduits shall have two locknuts and a bushing at each termination outlet box, junction box, etc., except where terminated in a threaded hub.

D. Patch all damaged areas of coating protection upon completion of installation.

2.9 SURFACE MOUNTED RACEWAY

A. **Surface mounted raceway shall only be used where noted on plans. If not noted on plans, the expectation is all conduit is concealed behind a wall, above a ceiling, or below a floor (even if concrete trenching is required).**

B. General Requirements
1. Surface mounted raceway shall be as manufactured by Wiremold, Panduit, Hubbell, or Monosystems. Part numbers listed in these specifications or the drawings refer to Wiremold products unless noted otherwise.
2. Furnish raceways with all elbows, fittings, boxes, clips, supports and accessories for a complete installation.
3. All field modifications to surface mounted raceway shall be made using the manufacturer's cutting tool with shearing action, maintaining clean joints, free from all burrs.
4. Furnish and install dividers in all raceways for which dividers are an option.

C. Small Raceway
1. Raceway shall be V500/V700 Series, V700 shall be used in all areas where V500 fill is exceeded, unless otherwise noted.
2. Raceway shall be steel. non-metallic
3. Raceway shall be ivory. white.
4. Raceway shall be painted to match wall color.
5. Raceway shall be used to route cabling and branch circuiting on existing walls in finished spaces only where noted. In mechanical, electrical, and data rooms conduit shall be used in lieu of surface mounted raceway. Refer to this specification section for all conduit requirements.

D. Prewired Raceway, Single Cell
1. Where indicated on the drawings the Contractor shall furnish and install single cell raceway factory prewired, for power or precut punched data covers with device spacing and wiring as indicated on the drawings.
2. Raceway shall be steel- Series 3000. aluminum- Series AL3000.
3. The raceway shall be furnished with covers in 12" lengths.
4. Refer to specification section 26 27 26 for wiring device requirements. If applicable, provide standard single gang opening for low voltage device faceplates. Contractor shall install low voltage wiring and terminate cables as required by Division 27. All accessories shall be provided with the raceway to accommodate low voltage cable install.
5. Custom, project specific shop drawings shall be submitted for review prior to rough-in.

E. Prewired Raceway, Two-Cell
1. Where indicated on the drawings the Contractor shall furnish and install two-cell raceway factory prewired, for power and precut punched data covers with device spacing and wiring as indicated on the drawings.
2. Raceway shall be aluminum- Series AL4000. stainless steel- Series S4000.
3. The raceway shall be furnished with covers in 12" lengths.
4. Refer to specification section 26 27 26 for wiring device requirements. Provide standard single gang opening for low voltage device faceplates. Contractor shall install low voltage wiring and terminate cables as required by Division 27. All accessories shall be provided with the raceway to accommodate low voltage cable install.
5. Custom, project specific shop drawings shall be submitted for review prior to rough-in.

F. Prewired Raceway, Three-Cell
1. Where indicated on the drawings the Contractor shall furnish and install three-cell raceway factory prewired, for power and precut punched data covers with device spacing and wiring as indicated on the drawings.
2. Raceway shall be aluminum- Series AL7320.
3. The raceway shall be furnished with covers in 12” lengths.
4. Refer to specification section 26 27 26 for wiring device requirements. Provide standard single gang opening for low voltage device faceplates. Contractor shall install low voltage wiring and terminate cables as required by Division 27. All accessories shall be provided with the raceway to accommodate low voltage cable install.
5. Custom, project specific shop drawings shall be submitted for review prior to rough-in.

G. Prewired Designer Raceway, Two-Cell
1. Where indicated on the drawings the Contractor shall furnish and install two-cell designer style raceway factory prewired, for power and precut punched data covers with device spacing and wiring as indicated on the drawings.
2. Raceway shall be aluminum- Series ALDS4000.
3. The raceway shall be furnished with covers in 12” lengths.
4. Devices shall be mounted in an upward-facing activation configuration where mounted above countertop backsplashes, all other locations shall be mounted in a downward-facing activation.
5. Refer to specification section 26 27 26 for wiring device requirements. Contractor shall install low voltage wiring and terminate cables as required by Division 27. All accessories shall be provided with the raceway to accommodate low voltage cable install.
6. Custom, project specific shop drawings shall be submitted for review prior to rough-in.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Minimum conduit size shall be ¾” trade size for branch circuits.

B. A bushing shall be used where conduit enters a panel box or equipment enclosure.

C. Grounding Bushings shall be used to bond conduits entering a panel box or equipment that are not mechanically connected.

D. All raceways for equipment and devices located within or on the building are to be routed through the interior of the building. Do not route conduits on the roof, surface mounted on the building exterior walls or via exterior trenches or directional bores between areas of the building, unless noted otherwise or prior approval is provided by the Architect/Engineer. (Engineer note: Per NEC 300.7(B), expansion fitting is required for raceways exposed to different temperatures.)

E. Expansion fittings shall be provided at all conduits across building expansion joints. Fittings shall be Type “AX” or “TX” as made by O Z Electric Company, or approved equal. Provide copper bonding jumper at each expansion fitting.

F. Conduit bends shall be made with standard benders of proper size; radius of bends to be at least 6 times the diameter of the conduit. Runs between outlets shall not contain more than the equivalent of three 90-degree bends. Conduit runs shall be continuous from outlet to outlet, outlet to cabinet, etc.

G. All exposed conduits shall be installed parallel or perpendicular to the building walls or floors.

H. Conduits shall be securely fastened to or supported from the building structure. Conduits not fastened directly to building structure shall be supported by a rigid assembly, free of sway and adequately braced, connected directly to the building structure. The use of ‘pencil’ wire, ceiling wire, and cable hangers shall not be permitted.

I. Anchor or stake down all direct burial conduits to prevent shifting during grading and concrete pours. Spacers shall be provided for trenches with 2 or more conduits with any conduit 2” or larger.

J. Install #12AWG pull wires for tracing for all underground non-metallic empty conduits with a minimum of 12 inches of slack on each end. Pull strings shall be used for empty above grade or metallic conduits.

K. All raceways installed within 1½” of the roof deck shall be GRS or IMC. Boxes shall be offset below the 1½”.

L. Conduits installed horizontally in finished spaces without ceilings shall be installed above the roof deck. These spaces include gymnasium, multi-purpose rooms and natatoriums. Conduit type for this application to be GRS or IMC in accordance with Article 300.4 of the National Electrical Code. Vertical drops from the roof deck shall be EMT and be routed along and attached to the structural steel.

M. All exposed raceways installed in a finished space will be painted to match the background, unless noted otherwise. Finished spaces include all areas open to the general public. Spaces such as storage, mechanical, IT, and electrical rooms and other similar areas only accessible to qualified personnel are considered unfinished.

N. All penetrations through non-rated walls shall be sealed for draft stopping with caulk, putty, etc. designed for this use.

O. Fire / Smoke seals:
   1. All penetrations through fire rated walls and floors shall be fire sealed in accordance with ASTM E814/UL1479 or manufacturer’s recommendations.
   2. Materials and installation details shall be submitted for approval.

**END OF SECTION 26 05 33**

# SECTION 26 05 34 – BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Pull boxes
2. Junction boxes
3. Outlet boxes
4. Outdoor boxes
5. Handholes
6. Manholes
7. Floor boxes
8. Poke-through boxes

### 1.2 ACTION SUBMITTALS

A. Product Data including all accessories, parts, and components required for a complete installation:
1. Outdoor boxes
2. Handholes
3. Manholes
4. Floor boxes
5. Poke-through boxes

B. Shop drawings:
1. Manholes

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 OUTLET BOXES, JUNCTION BOXES, FITTINGS

A. Pull boxes and junction boxes shall be installed where indicated on the drawings or where required to facilitate wire installation.
   1. Size: Outlet, junction, and pull boxes not dimensioned shall be 4-inch square by 2-1/8" deep minimum and comply with sizing as required by Article 314 of the National Electrical Code.

B. Steel faceplates must be used on fire rated drywall walls and painted to match device color. Faceplates shall be Mulberry Metal Products or equivalent.

C. All outdoor junction boxes and conduits shall be gasketed.

D. Handholes shall be installed where indicated on the drawings or where required to facilitate wire installation.
   1. Handholes not dimensioned shall be 12 inch by 12 inch by 12" deep minimum with open bottom and comply with sizing as required by Article 314 of the National Electrical Code. Handhole to be gasketed. Install on a minimum 6" gravel base with top of handhole flush with grade. Manufactured by Quazite or equivalent.
   2. Bolted style cover with gasket to match handhole. Include with "Electric" logo, unless noted otherwise.
   3. Handhole and handhole cover to be rated as Tier 22 loading.

E. Manholes shall be installed where indicated on the drawings.
   1. Manholes to be precast concrete and rated for H-20 structural load rating (medium duty)
   2. Manholes to be 6'-0" x 12'-0" x 8'-0" deep with 36" opening, unless noted otherwise.
   3. Cover to be solid, constructed of cast iron. Include with "Electric" logo, unless noted otherwise.
   4. Manhole accessories to include galvanized cabling racking and pulling irons on all four sides, sump pump pit and hook ladder.

## 2.3 FLOORBOXES AND POKE-THRU DEVICES

A. Furnish and install floorboxes and poke-thru devices as specified on the drawings. Equivalent products by manufacturers other than that shown on the drawings are acceptable unless noted otherwise.

B. Provide all accessories required for a complete installation.

C. Provide blank fillers or plates to cover all unused openings.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Mounting:
   1. Outlets must be centered with regard to paneling, furring, trim, etc.

2. Outlets shall be set plumb or horizontal and shall extend to finished surface of wall, ceiling, or floor without projecting beyond or behind finished surface.
3. Outlet boxes shall not be installed “back-to-back”. Provide at least 6 inch of separation or greater where required by the building code.
4. Electrical devices installed on Fire/Smoke partitions shall be installed with a 16 inch maximum opening on one side only in each framing space. All clearances between such devices and the gypsum board shall be completely filled with joint compound or other UL approved materials.
5. In fire rated drywall walls, 24” spacing must be maintained between boxes on opposite sides of walls. Moldable fire protective putty pads, firestopping coverplate gaskets, internal fire rated pads or other acceptable fire sealing means shall be installed on outlet boxes where the 24” spacing cannot be maintained.
6. 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
7. Set metal floor boxes level and flush with finished floor surface.
8. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
9. Finish plates shall not span different types of wall finishes either vertically or horizontally. Plates shall cover mortar joints and cut openings completely.
10. Outlet, junction and pull boxes, and their covers shall have corrosion protection suitable for the atmosphere in which they are installed. Provide gaskets for all boxes installed outside and other wet or damp locations (tunnels, crawl spaces, pits, etc.).
11. Outlet boxes shall be protected to prevent entrance of plaster, and debris shall be thoroughly cleaned from the box prior to installation of conductors.
12. Single gang opening outlet boxes shall be mounted with the long axis vertical unless otherwise noted for horizontal mounting. Three or more gang boxes shall be mounted with the long axis horizontal.
13. Finish plates shall be a type designed, intended, and appropriate for the use and location.
14. Existing outlet boxes are being reused, provide extension rings compatible with new wall surfaces or finishes.
15. Radiology/Imaging areas where lead shielding is required behind outlet boxes, Contractor shall provide such shielding.
16. Provide outlet box with barrier for grouped or ganged light switched where voltage between adjacent switches exceeds 300 volt AC per NEC Article 380.
17. Provide outlet box with barrier and separate conduit feed for switches grouped or ganged where connected to utility power and standby power.

B. Attaching: Boxes shall be attached by fastener designed for the purpose and shall provide adequate mechanical strength for future maintenance.
   1. Boxes installed in metal stud partitions shall be secured to the metal studs using appropriate clips, fasteners, hangers, or supports as required, and shall provide adequate far side box support to fulfill the intent of all applicable codes.

C. Firestopping: Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section “Firestopping”

D. In fire rated drywall walls, 24" spacing must be maintained between boxes on opposite sides of walls. Moldable fire protective putty pads, firestopping coverplate gaskets, internal fire rated pads or other acceptable fire sealing means shall be installed on outlet boxes where the 24" spacing cannot be maintained.

**END OF SECTION 26 05 34**

# SECTION 26 05 36 – CABLE TRAYS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Wire basket cable tray
   2. Center hung cable tray
   3. Ladder type cable tray

B. Furnish and install cable tray with all required accessories for a complete installation

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: To include Manufacturer's layout drawings in PDF format.

C. Seismic Restraint Design:
   1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and 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.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation instructions: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Wire Basket
   1. B-Line Flextray
   2. Hubbell Wire Basket Tray System
   3. Cablofil Wire Basket Tray
   4. MonoSystems Mono-Mesh

B. Center Hung
   1. Wiremold
   2. MonoSystems

C. Ladder Type
   1. B-Line

## 2.3 LADDER TYPE CABLE TRAY

A. Cable tray shall be stainless steel 6”siderail, ladder-type with 12” rung spacing

B. Cable tray widths shall be as indicated on drawings.

C. Cable tray fittings shall have a minimum of 36”radius.

D. Supports shall be wall brackets or trapeze type. Spacing per Manufacturer’s requirements.

E. Cable tray shall be capable of carrying a uniformly distributed load of 100 lbs./ft. on a 12 foot support span with a safety factor of 1.5 when supported as a simple span and tested per NEMA VE1 Section 5.2.

F. Furnish with all required accessories for a complete installation. Include expansion joint splice plates as required where temperature differentials will result in thermal expansion/deflection/contraction. Provide a support within two feet of each side of the expansion joint attached with expansion guides per manufacturer’s recommendations that permits linear movement of the tray without lateral deflection.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine existing conditions and adjust location for obstructions.

## 3.2 INSTALLATION

A. Cable tray shall be installed in such a manner and with proper parts to maintain an equipment ground path. Bond cable tray where non-continuous. Bond tray to the nearest effectively grounded material.

B. Conductors shall be securely bound in circuit groups (three phase conductors, neutral, and ground) with cable ties every three feet.

**END OF SECTION 26 05 36**

# SECTION 26 05 48 – SEISMIC RESTRAINT

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Seismic restraints for electrical systems

### 1.2 ACTION SUBMITTALS

A. Seismic restraint submittals shall be provided for engineer review and include, but not be limited to, detailed drawings showing seismic restraint types, anchor type and attachment details, calculations and spacing requirements of unique equipment and conduit for this specific project. Submittals shall include floor plan drawings indicating equipment, ductwork and piping to be restrained, restraint locations and restraint component types. All submittals and floor plan drawings shall bear the seal of a licensed structural engineer of the State of Missouri.

### 1.3 INFORMATIONAL SUBMITTALS

A. Product Data: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. As-built and field modifications shall be submitted.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

B. All materials and workmanship shall specifically comply with the above listed Building Code with respect to seismic requirements for the support and anchorage of all electrical, communications and electronic safety and security systems and equipment as installed on this project. Lateral forces to be restrained shall be as required by IBC Section 1621 Architectural, Mechanical, and Electrical Component Seismic Design Requirements and ASCE 7-02 Section 9.6 Architectural, Mechanical, and Electrical Components and Systems with the following design parameters with the design parameters as shown on the drawings:

1. Site Class as Defined in the IBC: Refer to Contract Drawings
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: Refer to Contract Drawings

C. All conduit support and restraint details and practices shall conform to the publication “Seismic Restraint Systems Guidelines” by Cooper B-line-TOLCO.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Submittals shall reflect the actual site conditions as verified by the Contractor.

3.2 INSTALLATION

A. Install all required seismic restraints per the provided submittals.

**END OF SECTION 26 05 48**

# SECTION 26 05 73 – ARC FLASH HAZARD ANALYSIS, SHORT CIRCUIT ANALYSIS, AND SELECTIVE COORDINATION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Arc flash hazard analysis
   2. Short circuit analysis
   3. Selective coordination

### 1.2 GENERAL INFORMATION

A. **The contractor shall be responsible for submitting the short circuit, arc flash and selective coordinate study prior to electrical equipment submittals. Electrical equipment submittals SHALL NOT be reviewed until the study has been completed.**

B. The contractor shall be responsible for revising electrical equipment submittals to accommodate the results of the study, to include breaker changes, AIC rating changes, etc.

C. Two separate studies shall be provided. One for Craig Hall and one for Art Annex.

### 1.3 ACTION SUBMITTALS

A. The results of studies shall be summarized in a preliminary and final report. The preliminary report shall be provided prior to submitted equipment approval. Electronic copies (PDF and native files) of the report shall be provided. The report shall include:
   1. A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
   2. Log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
   3. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses.
   4. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, minimum personal-protective equipment AFIE rating and AFIE (Arc Flash Incident Energy) levels.
   5. Arc Flash Labels shall be furnished and installed in accordance with NFPA 70E and all applicable local codes and standards.

6. Notify the engineer in writing, of any circuit protective devices improperly rated for the calculated available fault current, of any significant deficiencies in protection and/or coordination and of any significant deficiencies in protection and/or coordination.

B. The study shall include a separate, tabular printout containing the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram.

## 1.4 INFORMATIONAL SUBMITTALS

A. Not required.

## 1.5 CLOSEOUT SUBMITTALS

A. Not required.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. The contractor shall furnish an Arc Flash Hazard Analysis Study for all new distribution equipment, including but not limited to control panels, starters, disconnects, etc. per the requirements set forth in the current version of NFPA 70E. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2018.
   1. This study shall include the existing 5kV switchgear.
   2. This study shall include all Craig Hall equipment immediately upstream of the newest distribution equipment.

B. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer, licensed in the State of Missouri, and skilled in performing and interpreting the power system studies.

C. The studies shall be performed using the latest version of SKM Systems Analysis PowerTools for Windows (PTW) software program.

# PART 3 - EXECUTION

## 3.1 SHORT CIRCUIT ANALYSIS

A. Transformer design impedances shall be used when test impedances are not available.

B. Provide the following:
  a. Calculation methods and assumptions
  b. Selected base per unit quantities
  c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis. Labeling of components shall match the one-line and floorplans.
  d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions greater than 5HP, and other circuit information as related to the short-circuit calculations.
  e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
  f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.

C. For solidly grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.

## 3.2 PROTECTIVE DEVICE COORDINATION ANALYSIS

A. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

B. Include on each TCC graph, a complete title with descriptive device names.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:
  1. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands
  2. Low voltage equipment circuit breaker trip devices, including manufacturer’s tolerance bands
  3. Transformer full-load current, magnetizing inrush current, inrush/full load current multiplier, and ANSI through-fault protection curves
  4. Medium voltage conductor damage curves
  5. Ground fault protective devices, as applicable
  6. Pertinent motor starting characteristics and motor damage points, where applicable

7. The largest feeder circuit breaker in each motor control center and applicable panelboard.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

G. Final overcurrent device settings as identified by the protective device coordination study shall be implemented by the installing contractor.

## 3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in the latest version of NFPA70E, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis and the protective device time-current coordination analysis.

B. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

F. The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:

H. Fault contribution from induction motors should not be considered beyond 5 cycles.

I. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required, and it shall be based on a device located upstream of the equipment to clear the arcing fault.

J. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

K. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

L. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

**END OF SECTION 26 05 73**

## SECTION 26 08 00: COMMISSIONING OF ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.1 SUMMARY

A. The work under this Section is subject to requirements of the Contract Documents including the Owner's General Conditions and articles of the Construction Manager's General Conditions.

B. General commissioning requirements are detailed in Division 01.

C. The commissioning process does not reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product in accordance with the Contract Documents.

D. This section shall in no way diminish the responsibility of the Division 26 Contractors, Subs and Suppliers in performing all aspects of work and testing as outlined in the contract documents. Any requirements outlined in this section are in addition to requirements outlined in Division 01 and 26 Specifications.

### 1.2 RELATED DOCUMENTS

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

B. The requirements in this section are in addition to those specifically outlined in:

1. Section 01 91 13 – General Commissioning Requirements

### 1.3 ELECTRICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. The following equipment and systems shall be commissioned as part of this project. All general references to equipment and systems within this document refer only to those identified below:

1. Interior Lighting Controls
2. Exterior Lighting Controls

### 1.4 REFERENCES

A. Refer to Section 01 91 13 for applicable references for work associated with this section.

### 1.5 DEFINITIONS & ABBREVIATIONS

A. Refer to Section 01 91 13 for definitions and abbreviations for terms in this section.

### 1.6 COMMISSIONING TEAM

A. Refer to Section 01 91 13 for commissioning team members.

### 1.7 COMMISSIONING SUBMITTALS

A. Refer to Section 01 91 13 for additional required commissioning submittals.

## PART 2 PRODUCTS

### 2.1 TEST EQUIPMENT

B. Refer to Section 01 91 13 for additional test equipment requirements.

C. If not otherwise specified, the following minimum requirements apply.

1. Voltage measuring equipment (true RMS) shall have a certified accuracy of ±2% of reading with a resolution of 1V.

2. Amperage measuring equipment shall have a certified accuracy of ±2% of reading with a resolution of 0.1A.

## PART 3 EXECUTION

### 3.1 COMMISSIONING PROCESS OVERVIEW

A. Refer to Section 01 91 13 for an overview of the commissioning process.

### 3.2 ROLES AND RESPONSIBILITIES

A. Refer to Section 01 91 13 for roles and responsibilities of additional team members.

B. Electrical Contractor Responsibilities

1. Include costs for all commissioning requirements in contract price.

2. Provide all necessary certified technicians, tools, meters, and protective equipment to safely and accurately record measurements of energized components.

3. For lighting controls systems, provide factory trained technician who is familiar with the project specific programming to assist with FPTs.

4. Review all PFC and FPT test procedures to confirm applicability of required information.

5. Any tasks indicated within the PFCs and FPT test procedures do not override any other start-up and checkout tasks identified in Division 26. It is the EC’s responsibility to ensure the system is fully operational.

### 3.3 SCHEDULING AND COORDINATION

A. Refer to Section 01 91 13 for scheduling and coordination requirements.

### 3.4 PRE-FUNCTIONAL CHECKLISTS

A. Refer to Section 01 91 13 for PFC requirements.

B. Execution:

1. The EC shall assist the CxA with documenting PFC information for any energized equipment. EC shall provide appropriate personnel, equipment, and PPE to gather required.

### 3.5 START-UP AND INITIAL CHECKOUT

A. Refer to Section 01 91 13 for Start-Up and Checkout requirements.

## 3.6 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 13 for FPT requirements.

B. Execution:

1. The EC shall assist the CxA with documenting PFC information for any energized equipment. EC shall provide appropriate personnel, equipment, and PPE to gather required.

## 3.7 NON-CONFORMANCE AND COMMISSIONING ISSUES

A. Refer to Section 01 91 13 for information regarding Non-Conformance and Cx Issues.

## 3.8 OWNER TRAINING

A. The GC/CM is responsible for execution of Owner Training.

**END OF SECTION 26 08 00**

# SECTION 26 09 23 – LIGHTING CONTROL DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Occupancy sensors
   2. Digital countdown timers
   3. Dimmers

### 1.2 ACTION SUBMITTALS

A. Product Data

B. Wiring Diagrams

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Operating Instructions: For each type of product.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 OCCUPANCY SENSORS

A. Ceiling mounted occupancy sensors shall be dual-technology and white in color unless otherwise noted: Watt Stopper #LMDC-100 or approved equivalent.
   1. Sensors shall be programmed in accordance with the lighting control matrix.

B. Wall mounted occupancy sensors shall be dual-technology and white in color: Watt Stopper #LMPX-100 or approved equivalent.

1. Sensors shall be programmed in accordance with the lighting control matrix.

C. Wallswitch occupancy sensors shall be white in color and be Watt-Stopper #DW-311 or approved equivalent.
   1. Sensors shall be programmed in accordance with the lighting control matrix.

D. Provide occupancy sensors with relay packs as required or shown on the drawings.

E. Occupancy sensors shall be programmed to ‘manual-on’ unless otherwise specified.

F. Provide open plenum rated wiring in accordance with manufacturer’s wiring diagrams.

G. Rooms or areas with multiple sensors shall be wired so that any sensor activates all lights.

H. Sensors shall be installed a minimum of 6’ from all diffusers.

I. Refer to wiring diagrams on drawings for additional requirements.

## 2.3 DIGITAL COUNTDOWN TIMERS

A. WattStopper TS-400 or approved equivalent.

B. Countdown Timer to be programmed to the following:
   1. Storage Rooms – 10 minutes with audio and visual options disabled.
   2. Mechanical/Electrical Rooms – 30 minutes with audio and visual options enabled.

## 2.4 DIMMERS

A. Provide dimmer switches as shown on drawings. Dimmers will be a combination of wall mounted standalone devices and digital devices that operate by way of a lighting controller. See lighting control matrix for designation where analog vs digital devices are utilized.

B. Dimmers to be manufactured by WattStopper.

## 2.5 LIGHTING CONTROLLERS

A. Provide lighting controllers as shown on drawings. The plans designate 1, 2, or 3 zone controllers as required for a given space.

B. Dimming will be primarily 0-10v, though forward phase and/or reverse phase dimming will be ultiized at times. See plans for controller designations aligning with the luminaire selection basis of design. Where substitute fixtures are utilized, the EC shall coordinate the variations. See lighting control matrix for designation where standalone vs networked devices are utilized.

C. Lighting Controllers to be manufactured by WattStopper.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

### 3.3 INSTALLATION OF CONTACTORS

A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

### 3.4 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

A. Field tests must be witnessed by owner.

B. Tests and Inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 3 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide 1 visit to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

**END OF SECTION 26 09 23**

# SECTION 26 09 43 – NETWORK/ADDRESSABLE LIGHTING CONTROLS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Lighting control system
   2. Relays
   3. Switches

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop drawings: Project specific connection diagrams and riser diagrams

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Operating Instructions:
   1. Installation and programming instructions for all system components.
   2. Operating instructions for all system components.
   3. Relay schedule documentation.
   4. Switch schedule documentation.
   5. Time Clock schedule documentation.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 SYSTEM

A. Furnish and install a complete low voltage lighting control system consisting of relay control panels, switches and wiring to provide control as shown on the drawings.

B. Drawings contain devices necessary for control and typical wiring diagrams, lighting control vendor shall provide project specific wiring diagrams as part of the submittal package.

C. System shall be a 'Digital Lighting Management' System as manufactured by WattStopper.
   1. System shall be furnished with a handheld display unit for system programming of all devices and time clock functions.

D. System shall be networked to allow complete system control from any switch location, or setup as a hybrid approach allowing networking to be limited to the common areas and building mounted exterior.

E. Site pole and bollard lighting shall be controlled by BAS (Johnson Controls) by way of electrical contactor.

F. Refer to lighting control matrix for list of spaces to be networked vs standalone.

G. Contractor shall include the local manufacturer's rep to program the system as shown in contract documents.
   1. Contractor shall furnish panel directories indicating circuit designation, and area designation for each relay prior to startup.

## 2.3 RELAYS

A. Relays shall be mounted in control panels containing terminal strips, transformers, rectifiers, all interconnecting wiring and switch interface modules for multiple relays. Relays shall maintain position during power outages.

B. Lighting room controllers, shall be mounted in accessible locations above the ceiling.

C. Low Voltage Relays shall be 20A rated, mechanically held, with manual by-pass built-in.

## 2.4 SWITCHES

A. Switches shall be RJ45 connections via Category 5 cable (or better). The cabling shall be designed for open topology.

B. Switches shall have engraving per the drawings and engraving matrix.

C. Switches shall have LEDs indicating on/off status.

D. Switches shall be capable of being configured to control a single relay, a group of relays, or scene control.

E. Lighting Switches shall be Watt Stopper DLM as indicated on the drawings/wiring diagrams.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install per manufacturer's recommendations. Reference lighting control matrix for further detail on settings, meetings, and training necessary upon installation.

3.2 WIRING

A. All wiring shall be as required by the equipment supplier and tested prior to connection.

B. Wiring may be run as concealed open-type plenum rated cable. Exposed or inaccessible wring shall be installed in conduit. Where possible wiring/conduit shall be concealed.

3.3 TESTING AND CHECKOUT

A. The Contractor shall provide a representative from the company to conduct a 2-hour training class at a time scheduled in advance with the Owner and shall occur during or immediately following system startup. These instructions are to be conducted during normal working hours. All pertinent costs shall be included in this contract.

B. A follow up visit is required 3 months after occupancy to allow for adjustments desired by owner after use of the system.

3.4 IDENTIFICATION

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

3.5 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test continuity of each circuit.

2. Test dimming of each zone.

B. Tests and Inspections:
1. Test each controller using local and remote controls
2. Verify time schedules and photocell overrides.
3. Verify integration between lobby and theatre.

C. Nonconforming Work:

1. Lighting controls will be considered defective if they do not pass tests and inspections.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Field Test Reports:

1. Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

## 3.6 STARTUP SERVICE

A. The Contractor shall provide a representative from the company to conduct a 2-hour training class at a time scheduled in advance with the Owner and shall occur during or immediately following system startup. These instructions are to be conducted during normal working hours. All pertinent costs shall be included in this contract.

B. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Activate luminaires and verify that all lamps are operating.
3. Confirm correct communications wiring, initiate communications between DLM devices and controller/gateways, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.

## 3.7 ADJUSTING

A. Occupancy Adjustments: When requested within **3** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide **one** visits to Project during other-than-normal occupancy hours to support this purpose and review exterior lighting function.

**END OF SECTION 26 09 43**

# SECTION 26 09 61 – THEATRICAL LIGHTING CONTROLS

## PART 1 - GENERAL

### 1.1 WORK INCLUDED

A. The Electrical Contractor, as part of the work of this section, shall provide, install and test a complete lighting control system as specified herein for areas indicated on the drawings and circuit schedules.

B. The Electrical Contractor shall furnish all conduit, wire, connectors, hardware and other incidental items necessary for the complete and proper operation of the lighting control system.

C. The Electrical Contractor shall coordinate all work described in this section with all other applicable plans and specifications, including but not limited to:
   1. General Conditions
   2. Electrical Section General Provisions
   3. Conduit
   4. Wire and Cable
   5. Section 11 61 33 Performance Rigging

### 1.2 SYSTEM DESCRIPTION

A. The system shall be designed for the control of architectural and theatrical lighting and shall consist of factory pre-wired dimming and processing rack enclosures containing dimmers, relays, power supplies, breakers, terminals and/or control electronics.

B. System shall work in conjunction with specified low-voltage control stations.

### 1.3 SUBMITTALS

A. Manufacturer shall provide six (6) sets of full system submittals. Submittals shall include:
   1. Full system riser diagram(s) illustrating interconnection of system components, wiring requirements, back box sizes and any special installation considerations.
   2. Full set of printed technical data sheets.
   3. Detailed set of dimmer schedules
   4. Detailed set of circuit and control schedules, including a complete list of all deviations from specifications.
   5. Manufacturer shall provide any additional information, including equipment demonstrations, as required by the engineer or specifier to verify compliance with specifications.

## 1.4 QUALITY ASSURANCE

A. Manufacturer shall be one who has been continuously engaged in the manufacturer of lighting control equipment for a minimum of ten years. All dimmer and cabinet fabrication must take place in a U.S. manufacturing plant.
   1. The manufacturer shall have a factory authorized stocking service center with at least one full time service technician on staff located within 50 miles of the job site. In addition, the manufacturer shall have a toll free 24-hour hotline with a maximum response time of 20 minutes, 24 hours a day and 365 days a year.
   2. All equipment, where applicable standards have been established, shall be built to the standards of Underwriters Laboratories, Inc., the National Electric Code and the United States Institute for Theater Technology. Permanently installed power distribution equipment such as dimmer racks and distribution shall be UL and C-UL Listed, and/or CE marked (where applicable) and bear the appropriate labels. Portable equipment such as consoles and fixtures shall be UL and C-UL Listed, ETL Listed and/or CE marked (where applicable) and bear the appropriate labels.

## 1.5 ACCEPTABLE MANUFACTURERS

A. The equipment herein specified shall be manufactured by
   1. Electronic Theatre Controls
   2. Wenger / JR Clancy
   3. Philips
   4. Chauvet
   5. Approved Equivalent

B. Alternative manufacturers must submit a full pre-approval package ten days prior to bid date.

C. Permission to bid does not imply acceptance of the manufacturer. It is the sole responsibility of the electrical contractor to ensure that any price quotations received and submittals made are for controls systems that meet or exceed the specifications.
   1. Touchscreen Control Stations
      a. The Touchscreen Control Stations shall be the Unison Paradigm Touchscreen P-TS7 Series Control Stations as manufactured by ETC, Inc., or equal.
   2. General
      a. Touchscreen stations shall support default and fully graphical control pages.
      b. The Touchscreen station shall operate using graphic buttons, faders and other images on at least 30 separate programmable control pages.
      c. Touchscreen stations shall also allow programming of page pass-code, lock out and visibility levels.
   3. Mechanical
      a. Touchscreen stations shall consist of a seven inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels and 24-bit color depth with a capacitive touch interface.
      b. Touchscreen bezels shall be constructed of cast aluminum finished in a fine texture powder coat.
         1) Touchscreen shall be available in five standard colors
            a) Cream (RAL 9001)
            b) Ivory (RAL 1015)

c) Gray (RAL 7001)
d) Black (RAL 9004)
e) Signal White (RAL 9003)
2) The bezel shall have no visible means of attachment.
3) The bezel shall allow the touchscreen to be installed and removed without the use of tools
4) The bezel shall provide two working positions for the Touchscreen: service and normal operation.

c. Touchscreen shall offer optional hinged locking covers
1) Locking covers shall be made from cast aluminum and be painted to match standard touchscreen color options
2) Locking covers shall allow for viewing of system status on the touchscreen though a smoked Lexan window

d. The manufacturer shall provide back boxes for all LCD stations.
1) Flush back box for Touchscreens with or without locking covers shall be 7.94" wide x 5.33" high x 3.25" deep
2) Surface back box dimensions shall be 8.3" wide x 5.6" high x 2.75" deep
3) Surface back box for Touchscreens with locking cover dimensions shall be 10.0" wide x 6.7" high x 2.75" deep

4. Electrical
a. Touchscreens shall be powered entirely by the System network.
b. Touchscreens shall connect to the System using an Ethernet network with Power over Ethernet (PoE) or the Unison control station Echelon® Link power network.
1) Ethernet Network
a) Ethernet network shall be 10/100BaseTX, auto MDI/MDIX, 802.3af (PoE) compliant.
b) Network shall utilize Unshielded Twisted Pair (UTP) Category 5, or better wiring.
c) PoE power consumption shall be PoE class 2, consuming no more than 6 watts.
2) Echelon® Link power network.
a) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
b) Touchscreen stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
c) Network wiring may be bus, loop, home run, star or any combination of these.
d) Network insulation displacement connectors shall be provided with all stations.

5. Functional
a. System
1) The Touchscreen shall support configuration firmware upload from a Paradigm Processor as proxy
2) The Touchscreen shall support configuration or firmware upload from local removable media
b. Setup Mode
1) There shall be a setup display that is separate from any user-defined configuration
2) It shall be possible to view and modify connectivity settings

3) It shall be possible to view status information
4) It shall be possible to view and modify LCD screen settings
5) It shall be possible to perform Touchscreen calibration
6) It shall be possible to view and modify audio settings
7) The appearance of the setup display shall be standard and not editable
8) The setup display may be invoked from within the user-defined configuration and/or physical button on the Touchscreen
9) There shall be a default protected method to invoke the setup display

c. Configurations
1) It shall be possible to have multiple configurations stored within an LCD Station
2) Where multiple configurations are stored there shall be a boot menu to allow selection of a configuration

d. Operation
1) The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Touchscreen controls. System shall allow the control of presets, sequences, macros and time clock events.
a) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.

Presets shall have a discrete fade time, programmable from zero to 84,600 seconds with a resolution of one hundred milliseconds.

Presets shall be selectable via Touchscreen stations.

2) System macros and sequences shall be programmable via LightDesigner system software.
a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
3) System time clock events shall be programmable via the Touchscreen, LightDesigner system software, the processor user interface, or the internal web server.
a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.

e. A Color picker, supporting Hue, Saturation and Brightness (HSB) color selection shall be available for color selection of color changing fixtures and provide visual feedback of the current color produced by the associated fixture.
1) The color picker shall be provided with a default layout that requires no user configuration
2) The Color Picker shall provide RGB faders in addition to the default HSB color wheel for color selection
3) Color picker values shall allow for numerical value input in addition to color wheel and fader control

4) The color picker shall be compatible with color mixing systems that use up to seven discrete color control channels

f. Touchscreen stations shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
   1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, and cue light, or room join/separate.
   2) Optional fader functions include master control, individual channel control, fade rate control or preset master control.

g. Touchscreen stations shall allow programming of station and component electronic lockout levels via LightDesigner.

h. It shall be possible to adjust LCD contrast and brightness.

i. It shall be possible to program the station to dim during periods of inactivity.

6. Control Processor Modules

a. The Architectural Control Processor shall be the Unison Paradigm Series, P-ACP Control Processor as manufactured by Electronic Theatre Controls, Inc., or equal.

b. Mechanical
   1) The Architectural Control Processor (ACP) assembly shall be designed for use in DRd Series Power Enclosures and ERn Series Control Enclosures.
   2) The processor shall utilize microprocessor based, solid state technology to provide multi-scene lighting and building control.
   3) ACP module electronics shall be contained in a plug-in assembly.
      a) The module shall be housed in a formed steel body and contain no discrete wire connections.
      b) No tools shall be required for module removal or insertion.

c. The ACP shall be convection cooled.
   1) User Interface
      a) The ACP shall utilize a backlit liquid crystal display capable of graphics and eight lines of text.
      b) The ACP shall provide an alpha-numeric keypad for data entry and navigation.
      c) The ACP shall provide a touch-sensitive control wheel for navigation.
      d) The ACP shall provide shortcut buttons to assist in navigation, selection, and data entry.
      e) The ACP keypad, buttons, and wheel shall be backlit for use in low-light conditions.
      f) The backlight shall have a user selectable time out, including no time out.

d. The ACP shall provide a front-panel RJ45 receptacle for Ethernet connection to the processor for configuration, live control, and web-browser-based system access.
   1) The RJ-45 receptacle shall be secured behind the locking door.

e. The ACP shall provide a Secure Digital (SD) Removable Media slot on the front panel for transfer of configuration data.

f. The SD slot shall be secured behind the locking door.

g. The ACP shall provide a Universal Serial Bus (USB) port on the front panel for transfer of configuration data.

1) The USB port shall be secured behind the locking door.

h. Architectural Lighting System configuration and program information shall be stored in flash memory, which does not require battery backup.
   1) The ACP shall provide a Compact Flash (CF) Card as backup flash memory and storage.
   2) The CF Card is located in the back of the ACP, and can be accessed only by removing the ACP.
   3) The ACP data can be exchanged by inserting the CF card into another ACP.

7. Electrical
   a. The ACP shall require no discrete wiring connections; all wiring shall be terminated into Dimming or Control Enclosure.
   b. The ACP shall require low-voltage power supplied by the Dimming or Control enclosure.
   c. The ACP shall be hot-swap capable.
   d. The ACP shall support Echelon LonTalk with LinkPower communications with control stations and other remote devices, including button stations, button/fader stations, Touchscreen stations, sensors, and third party LonMARK compliant products.
      1) The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit. Touchscreen stations, interface stations and portable stations connectors will also require (2) #16 AWG wires.
      2) The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.
      3) Link power wiring shall permit a total wire run of 1640 ft. (500m) without a repeater. Repeater option modules shall be available to increase wiring maximums in increments of 1640 ft. (500m).
      4) Link power wiring between stations shall not exceed 1313 ft. (400m).
   e. The ACP shall support 10/100BaseTX, auto MDI/MDIX, 802.3af compliant Ethernet networking using TCP/IP, ESTA BSR E1.17 Advanced Control Networks (ACN) and ESTA BSR E1.31 (sACN) Protocols for internal communication and integration with third-party equipment.
   f. The ACP shall support EIA-RS232 serial protocol for bi-directional command and communication with third-party equipment.
   g. The ACP shall support two discrete ESTA DMX512A ports, configurable as input or output ports.*
      1) *When used in a Dimming Enclosure, the second port is always an output port.
   h. The ACP shall provide four onboard dry contact closure inputs for integration with third-party products.
   i. The ACP shall provide four onboard contact closure outputs, rated at 1A@30VDC, for integration with third-party equipment.

8. Functional
   a. Capacity
      1) Shall support 1024 channels of control
      2) Shall support 2 physical DMX ports, each of which may be configured as an input or output
   b. System
      1) Runtime application shall utilize support Net3 system interoperability

2) System shall support the use of Network Time Protocol for real time clock synchronization
3) System shall support remote firmware upload an over Ethernet connection from a connected PC running the Light Designer software or another connected processor.
4) System shall support local firmware upload from removable media (SD Card, USB Flash Drive)

c. Diagnostics
1) Shall output an Event log
2) Standard log shall store a fixed-length history of recent activity
3) Separate critical log shall only store important messages (such as boot-up settings)

d. Configuration Data
1) Configuration Data can be uploaded over an Ethernet connection from a PC running Light Designer application
2) Configuration Data can be retrieved from another Paradigm Processor
3) A Paradigm Processor shall make its configuration data available for retrieval by another Processor as a backup/recovery mechanism
4) Configuration Data shall be stored on solid-state media that can be removed to facilitate transfer between Processor units
5) Configuration Data may be loaded to and from removable media access provided on front panel
6) Configuration Data for the entire System shall be available for download from any single Processor
7) Shall store configuration data for Dimming enclosure processors and shall make available for download

e. Scalability
1) Adding additional Processors to a System shall proportionately increase its overall capabilities up to a maximum project size
2) The maximum number of Processors configured as a project shall be at least 12. The use of a Central Control Processor (P-CCS) shall allow for larger system sizes up to 64 processors
3) Multiple Processors shall utilize the Ethernet network to remain time synchronized and share control information
4) Multiple Processors shall utilize the Ethernet network to maintain configuration data synchronization as modifications are made
5) Failure of a single Processor shall not prohibit continuing operation of the remaining Processors
6) It shall be possible for multiple Systems to coexist on the same physical network with logical isolation between Systems

f. Local User Interface
1) Shall provide access to Processor setup (IP address)
2) Shall provide access to Processor status and diagnostics
3) Where the Processor is installed within a Dimming enclosure, shall provide access to Dimming enclosure setup, status and diagnostics
4) Shall provide control functionality for Control Channels, Zones, Fixtures, Groups, Presets, Macros, Walls and Sequences within the current configuration.
5) Shall provide functionality to schedule astronomical and real time events (add/edit/delete)

6) Shall allow for display of local DMX information
7) Shall allow for transfer of log files to local removable media
8) Shall allow to perform firmware upgrades for connected Dimming enclosures
9) Shall allow for transfer of configuration to and from Dimming enclosures using removable media
10) Shall allow for transfer of configuration to and from LCD Stations using removable media
11) Shall allow for binding of Stations

g. Access Controls
1) There shall be 2 user accounts - Administrator, and User with separate password protection
2) Account and password settings shall be local to each Processor
3) Access Controls shall be applied to certain areas of the Paradigm Local User Interface and Web Interface

h. Web User Interface
1) Shall be an internal web server accessible via Ethernet port
2) Shall support common web browsers on Windows and Mac platforms
3) Shall provide functionality to Activate and Deactivate Presets
4) Shall provide functionality to schedule timed events (add/delete)
5) Shall display status information
6) Shall display log files
7) Shall allow for configuration of Processor settings (date, time)
8) Shall allow for upload and download of configuration data
9) There shall be links to other web-enabled devices in the System, including other Paradigm Processors

i. Stations
1) Stations shall be connected to a Paradigm Processor via a LinkPower network or Ethernet
2) Station discovery and binding shall be accomplished from the Local User Interface or Light Designer

j. Net3 and ACN Devices
1) Paradigm Processors shall provide DMX-Net3 gateway functionality
2) Net3 devices shall be connected to and controlled from the Processor via Ethernet
3) It shall be possible to send and receive Macro triggers defined within the System configuration via Net3
4) There shall be support for a maximum of 1024 Streaming ACN outputs configured to a maximum of 12 universes per Processor

k. Operation
1) When contained in a dimming enclosure, a snapshot of the dimming enclosure output data shall be stored in persistent memory so that hardware can access it for immediate output on boot
2) DMX output refresh rate shall be configurable
3) There shall be support for 16-bit DMX Attributes
4) DMX inputs may be patched to DMX and Streaming ACN outputs as external sources
5) Streaming ACN inputs shall be patched to DMX outputs (gateway) as external sources
6) Where there are multiple external sources then priority and HTP shall be used to perform arbitration

7) External and internal sources shall be arbitrated based on user-selection of standard or custom rules
8) On Preset Record, the values of Attributes within the Preset shall be updated to reflect the current output
9) The total output may be the combination of many different Presets running concurrently
10) There shall be no hard limit on number of concurrent cross fades
11) Multiple Presets controlling the same Attribute shall first interact based on priority and second based on Latest Takes Precedence (LTP) or Highest Takes Precedence (HTP)
12) LTP and HTP operation shall be supported simultaneously and interact (at the same priority) using HTP
13) Settings due to LTP Presets may be automatically discarded from operation when overridden
14) It shall be possible to specify that a Preset or Attribute Control will persist when overridden
15) A Preset may be designated as an HTP Override and shall cause HTP values to be discarded
16) It shall be possible to modify the rate of a Preset (Cross fades, Effects) from a Control within the System
17) Each Preset shall have a status that can be Activated, Deactivated or Altered
18) Preset status may be set based on matching levels in the current output as an option
19) On startup the System shall be capable of automatically executing timed events within the previous 24 hours to synchronize its initial output state with the current time of day

l. Serial Input/Output
1) RS232 shall support 8-bit word length, parity selection and 1 or 2 stop bits
2) RS232 shall support baud rates from 4800 to 115,200 bps
3) Serial input and output messages are fully customizable
4) Serial output messages can be generated by any Control or Event
5)

9. Button and Fader Stations
a. General
1) The control station shall be the Paradigm Inspire Station Series as manufactured by ETC, Inc., or equal
2) It shall be a remote station on a LinkConnect network that can recall presets, provide direct zone control, play macros and provide room combine actions for a control system
3) The station shall consist of a dual function (control/ record) push-button with an integral tri-color backlight for each corresponding button and fader

10. Mechanical
a. Control stations shall operate using one, two, four, six or eight buttons. A four button with fader station shall also be available
b. All button stations shall be available with cream, grey, black or white decorator style faceplates
1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard
c. Stations shall have tri-color backlights for each button and fader
1) Indicators shall utilize a configurable color backlight for active status

2) Indicators shall utilize a configurable color backlight for inactive status to assist in locating stations in dark environments. Stations that do not support a lit inactive or deactivated state shall not be accepted
3) Stations shall support an off backlight state of inactive status when required

d. All faceplates shall be designed for flush or surface mounting and have no visible means of attachment
e. Station faceplates shall be constructed of ABS plastic and designed based on a standard decorator style faceplate.
f. Buttons shall be indelibly laser marked for each button function
g. Control station electronics shall mount directly behind the faceplate. The entire assembly shall mount into a single gang back box. Back boxes for flush mounted stations shall be industry standard back boxes. The manufacturer shall supply back boxes for surface mounted stations.

11. Electrical
a. Control station wiring shall be LinkConnect control wiring utilizing low-voltage, Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
b. The station shall operate on class 2 voltage provided by the control system via the LinkConnect network.
c. Station wiring must be topology free. It may be point-to-point, bus, loop, home run or any combination of these.
d. Wiring termination connectors shall be provided with all stations.
e. Control stations shall be UL/ cUL listed and CE marked and meet WEEE Compliance

12. Functional
a. The Control System shall be designed to allow control of lighting and associated systems via Button and Fader controls.
1) System presets shall be programmable via LightDesigner configuration software.
a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
2) System macros and sequences shall be programmable via LightDesigner configuration software.
a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.

b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.
1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.
2) Optional fader functions include manual master control, individual zone control, color control fade rate control or preset master control.
3) Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.
4)

1.6 DMX/DRM ETHERNET Gateway – One Port

A. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX-512 data to be encoded, routed over an Ethernet network and decoded back to DMX-512. The gateway shall be a DMX/RDM 1-port Gateway as provided by ETC, Inc.

B. Gateways shall communicate over Ethernet directly with at least ETC, Inc.' s entertainment and architectural lighting control products and other Ethernet interfaces.

C. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.

D. The gateway shall support multiple protocols including:
   1. ANSI E1.17 Architecture for Control Networks (ACN)
   2. ANSI E1.31 Streaming ACN (sACN)
   3. ANSI E1.11 USITT DMX512-A
   4. ANSI E1.20 Remote Device Management (RDM)

E. The gateway shall be tested to UL standards and labeled ETL Listed.

F. The gateway shall be RoHS Compliant (lead-free).

G. The gateway shall be CE compliant.

H. Each gateway shall have LED indicators for Power, DMX activity/ status, and network activity

I. The gateway shall be configurable using a software configuration tool.

J. DMX Ports:
   1. DMX Port shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.
   2. The DMX port shall be software-configurable for either input or output functionality.
   3. DMX input shall be optically-isolated from the gateway electronics.
   4. DMX output shall be earth-ground referenced.
   5. DMX Port shall be capable of withstanding fault voltages of up to 250vAC without damage.
   6. The DMX port shall incorporate one DMX512-A Connection
      a. The DMX port location shall support a single 5-pin male XLR or 5-pin female XLR or terminal strip
   7. Network gateways that do not indicate input/ output port configuration or indication of valid data shall not be accepted.

K. Processor
   1. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 addresses).
   2. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 mSec.).

3. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility with 3rd party DMX devices.

L. Mechanical
1. The gateway shall be available in three versions
a. Wall-mount gateway
1) The gateway faceplate shall be constructed of cold-roll steel and be formed for use with any standard Decorator style faceplate
2) A color matched faceplate shall be provided with the gateway
3) Wall-mount gateways shall be painted using a fine-texture powder coat paint and be available in Cream (RAL9001), Black (RAL 9004) or White (RAL9003). A matching Lexan overlay shall provide labeling of LED status indicators
4) The gateway shall support flush mounting using a standard RACO 1-gang, deep backbox or equivalent.
a) Surface mounting shall also be supported using a manufacturer supplied backbox.
5) Dimensions shall not be more than 2.75" (70mm) wide x 4.5" (115mm) High
b. Portable gateway
1) The portable gateway shall include a complete enclosure finished in a black fine texture powder coat paint
2) Two wiring connections shall be required for connection to the lighting system
a) Ethernet connection that supports standard Cat5 patch cables or Ethercon cables. Gateways that do not support the use of Ethercon cables shall not be accepted
b) DMX input or output connection using is 5-pin XLR style connector
c. Dimensions shall not be more than 4.5" wide (115mm) x 3.5" (89mm) deep x 6.34" (161mm) high (not including mounting hardware)
2. DIN Rail Mounted
a. The DIN Rail mounted gateway shall be included in an extruded aluminum enclosure.
b. Two wiring connections shall be required for connection to the lighting system
1) Ethernet connection that supports standard Cat5 patch cables
2) DMX input or output connection using is terminal strip style connector
c. Dimensions shall not be more than 5.28" wide (134mm) x 4.13" (105mm) deep x 1.22" (31mm) high (not including mounting hardware)

M. Power
1. Power for the gateway shall be provided over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 5 watts.
2. An optional 8-28vDC power input shall be available for all wall-mount and DIN Rail mount gateways
3. The gateway electronics shall be electrically isolated from the power supplied over the Catagory5 (or better) cable.

N. Configuration

1. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required for configuration, and shall not be required for normal operation of the system.
2. Each DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes. The specific DMX data input or output by the gateway shall be freely configurable by the user.
3. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.
4. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway.
5. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the configuration PC to be online. Gateways that do not support non-volatile storage of data routing shall not be accepted

O. Network
1. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.
2. All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
3. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.
4. ANSI E1.17 Architecture for Control Networks (ACN) and ANSI E1.31 streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.
5. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.
6. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 63,399 universes (32,767,488 addresses) using Streaming ACN (sACN).
   a. Any range of DMX addresses may be selected for each universe.
   b. Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.
      1) Each DMX port shall support its own universe and start address.
   c. Gateways shall support built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent channel priorities shall not be accepted.

P. Environmental
1. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).
2. The storage temperature shall be -40° to 70°C (-40° to 158°F).
3. The operating humidity shall be 5% - 95% non-condensing.

Q. Accessories
1. Hanging bracket kit shall allow gateway to be mounted using C-Clamp to U-bolt Hardware.
2. ETC Net3 Concert Configuration and monitoring Software

R. System Requirements

1. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of Middleton, WI.
2. Provide Ethernet switches and power supplies as scheduled and as shown on drawings.
3. Provide a current generation PC with Windows 7 operating system equipped with a 10/100 Ethernet card.
4. Systems that do not provide the above capabilities shall not be acceptable

1.7 GENERAL NETWORK

A. The Electronic Theatre Controls Net3 network shall provide data distribution over TCP/IP Ethernet networks. Data shall be layer 3 routable. Systems using proprietary formats or formats other than 10/100/100Mbit wired Ethernet or non-layer 3 routable networks shall not be accepted.

B. Connections shall be made between consoles, face panels, architectural processors, dimmers, Net3 Gateways, and computers over standard Ethernet distribution systems using 100BaseT, 100BaseFL, or greater wiring. All installations shall conform to established Ethernet wiring practice, and installation shall be performed by contractors qualified to do this type of work. All wiring shall be tested at Category 5e or higher for full bandwidth operation to the appropriate IEEE standard.

C. The Lighting Control system must be supplied by a single manufacturer and must have seamless integration over Ethernet between the Entertainment and Architectural lighting control.

D. Capacities:

1. The network shall support DMX routing, patching, and prioritization for up to 63,399 universes (32,767,488 DMX addresses). Each address may be input or output from any port on any DMX gateway in the system. DMX input, routing and output shall be specifically supported on the system from multiple sources and locations up to the maximum number of gateways supported by the Ethernet topology.
2. The network shall support multiple network hosts including consoles, gateways, dimming racks, computers, file servers, printers, and architectural control processors with discrete command lines and control. The lighting network shall support multiple venues within a system and discrete systems on the same network.
3. System Configuration and Monitoring:

   a. Network device configuration shall be via Net3 Gateway Configuration Editor (GCE) software and/or ANSI E1.17 Architecture for Control Networks (ACN).
4. Patch addresses shall support viewing and manipulation via ANSI E1.17 ACN.
   a. The system shall permit complete user flexibility allowing the system operator to patch each DMX input address to any ANSI E1.31 streaming ACN address, and DMX output to span streaming ACN universes.
   b. The lighting system shall support assignment of DMX offsets, truncation of DMX universes, and provide choice of DMX port prioritization.
   c. The lighting system shall support the DD start code extension to ANSI E1.31 which provides priority per address such that multiple control sources can share universes with discrete control per address.

d. Lighting systems that do not support the above mentioned address patching capabilities shall not be suitable.

5. The system shall allow assignable labels for all network devices to allow easy identification by system users.
6. Each network device shall have a discrete and unique IP address provided automatically by the software. The user may edit this IP address. Systems that do not support automated IP allocation with IP collision avoidance, and systems that do not allow complete reconfiguration of the above mentioned features over ANSI E1.17 ACN shall not be acceptable.
7. All configuration data for each network device shall be held at the device and system operation shall not require continuous on-line operation of the network configuration software.
8. Lighting console operators shall be able to backup the network configurations in the lighting control console. In the event of a network device failure, the operator shall be able to apply the configuration of the failed device to a replacement device of the same type without manually reentering settings. Systems that do not support configuration backup as described above shall not be accepted.
9. Architectural and Entertainment systems connected to the same network shall be capable of arbitrating control over E1.31 Streaming ACN (sACN) level data. The system shall be capable of alternating control of individual address data between architectural and entertainment systems without intervention by the user. The user shall dictate the conditions under which system shall automatically take control. The network shall allow user override of the selected defaults. Systems which require direct user intervention to allocate control of dimmers between architectural and entertainment lighting systems shall not be accepted.
10. The Net3 network shall allow multiple DMX input sources to be prioritized on the same universe as network native sources using E1.31 Streaming ACN prioritization. Multiple DMX inputs may be assigned to the same streaming ACN address (this provides multi-source control for a particular address). Likewise, the system shall support E1.31 prioritization of multiple simultaneous network sources. Systems that cannot prioritize multiple DMX inputs and multiple native network sources on a network shall not be deemed suitable.
11. The lighting network shall allow each DMX input address to be assigned a priority on the network allowing each DMX control level coming into the system to participate in full arbitration. Addresses with the highest priority shall have control, with lower priority addresses being ignored. Addresses assigned the same numeric priority, between 1 and 200, shall respond in highest level takes precedence (HTP) manor. The network shall require a valid DMX signal present at the input to initiate prioritization. Systems that do not allow for prioritized HTP for DMX inputs to the network shall not be allowed.
12. Operational Features
    a. Each DMX gateway shall control up to 512 DMX addresses per port, within the confines of up to 63,999 DMX universes (32,747,488 address). The specific DMX data input or output by the gateway shall be configurable by the user.
13. Duplicate outputs of DMX data (DMX splitter) and discrete outputs shall be fully supported.
14. Merging of multiple DMX input sources on a single gateway without gateway with DMX output on the same gateway shall be supported without connection to the network. The gateway shall support assignment of priority to each input source independently
15. File transmission, synchronization and access to software shall be supported.

1.8 I/O GATEWAY

A. The lighting control gateway shall be a microprocessor-based unit specifically capable of providing multiple separate connections to serial, analog input, and relay output. The gateway shall encode serial, analog input and relay output packets to be routed over the Ethernet to network lighting products. The unit shall be a Net3 I/O Gateway as provided by ETC, Inc.

B. Gateways shall communicate over Ethernet directly with at least ETC, Inc.' s entertainment and architectural lighting control products and other Ethernet interfaces.

C. Connections made between all gateways, consoles, architectural systems, dimmers, and configuration PCs shall be over standard Ethernet distribution systems using 10/100BaseT (or better). All installations shall conform to established Ethernet wiring practice and installation shall be performed by contractors qualified to do this type of work. All wiring shall be tested at Category 5e or higher for full bandwidth operation to the appropriate IEEE standard.

D. A minimum of 6 communication sessions shall be supported simultaneously over the networked lighting system. Each Gateway unit shall be capable of receiving 1 unique bidirectional RS232 serial stream, 24 analog inputs, and 16 relay outputs simultaneously. Systems that cannot provide connection to multiple Gateways simultaneously shall not be acceptable.

E. Network transport of RS232, analog inputs, and relay output shall comply with the requirements of the ANSI E1.17 Architecture for Control Networks (ACN) standard.

F. The unit shall be tested to UL standards and labeled ETL Listed.

G. The unit shall be RoHS Compliant (lead-free).

H. The unit shall be CE compliant.

I. The gateway shall have a backlit graphic LCD display for identification (soft-labeling) and status reporting. Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN) or Gateway Configuration Editor (GCE).

J. Each gateway shall have power and network activity LEDs on both the front and rear of the unit.

K. Mechanical:
   1. The gateway shall be suitable for rack mount, pipe mount and portable, applications.
      a. The gateway shall be fabricated of 16-gauge steel and finished in a fine-texture, scratch-resistant, black powder coat. Dimensions shall be 8.5" (22 cm) wide x 8.0" (20 cm) deep x 1.75" (5 cm) high.
      b. The weight of the gateway shall be 3.5 lbs (1.6 kg) with four connector modules. An individual module shall weight no more than .25 lbs (.1 kg).
      c. Mounting holes shall be provided for installation of a pipe mount accessory kit.
   2. Power
      a. Power for the gateway shall be provided either over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet distribution equipment, or via conventional switches together with isolated in-line power supplies capable of an operating range of 8-28vDC provided by the gateway manufacturer. Power consumption shall not be greater than 5 watts.

b. The gateway electronics shall be electrically isolated from the power supplied over the Cat5 cable.
c. Power may be provided from IEEE 802.3af compliant power-over Ethernet distribution equipment, or by using conventional switches together with isolated in-line power supplies as provided by gateway manufacturer.

3. Configuration

a. Each gateway on the network shall be individually configurable using any device utilizing ANSI E1.17 ACN communications
b. Gateway Configuration Editor (GCE), running on a network connected PC. The PC shall only be required for configuration, labeling and signal routing, and shall not be required for normal operation of the system.
c. All applicable serial port settings, analog input trigger levels and relay output connection settings as well as stream ID' s shall be configurable using ANSI E1.17 ACN communications on the Ethernet network.
d. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring software configuration

4. 14. Network

a. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications
b. All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
c. All network communications shall be suitable for use on routed networks. Thus communication shall capable of being filtered or passed through Layer 3 switches (routers). Gateway products that implement protocols that do not support routed networks shall not be acceptable.
d. All networks shall support ANSI E1.17 Architecture for Control Networks (ACN) and ANSI E1.31 streaming ACN (sACN) shall be supported.
e. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.

5. Environmental

a. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).
b. The storage temperature shall be -40° to 70°C (-40° to 158°F).
c. The operating humidity shall be 5% - 95% non-condensing.

6. Accessories

a. A hanging bracket kit shall allow unit to be mounted in 3 orientations. U-Bolt or c-clamp options shall be available
b. A one E.I.A. rack space mounting bracket kit shall support either one or two complete units
c. A Universal Power Supply with international plug-set included. Multiple power supplies shall be able to fit in a vertically stacked power strip.
d. Gateway Configuration Editor Software (GCE)

7. System Requirements

a. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of MiddletonWI
b. Provide Ethernet switches and power supplies as scheduled and as shown on drawings.

c. Provide a current generation PC with Windows XP operating system equipped with a 10/100 Ethernet card.
d. Systems that do not provide the above capabilities shall not be acceptable

1.9 M. POWER DISTRIBUTION – CONNECTOR STRIPS

A. General

B. Connectors shall be available as 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A "U" ground (dual rated "T-slot"); other connectors shall be available as specified.

C. Internal wiring shall be sized to circuit ampacity and shall be rated at 125°C.

D. Pigtails shall be three-wire type "SOW" rubber jacketed cable sized for the maximum circuit ampacity.

E. Pigtails with 20 amp stage pin connectors shall be terminated using 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket.

F. Terminations shall be at one end using feed-through terminals individually labeled with corresponding circuit numbers.
1. a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire.
2. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire.
3. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire.
4. Terminals that place a screw directly on the wire are not acceptable.

G. Connector strips shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings
1. Connector strips shall have junction brackets on 5' centers.
2. Brackets shall be 1½" x .188" ASTM A 36 steel
3. Hardware shall be ASTM A307 grade 5.

H. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified in the connector strip. Connector strips shall utilize a voltage barrier to accommodate these systems. Low Voltage signals shall enter the connector strip via a strain relief or connector mounted in a separate low voltage terminal box at the specified end of the connector strip. Up to four low voltage cables shall be supported for each connector strip.
1. Connector strips with multiple DMX outputs from the same source shall use DMX pass through assemblies consisting of a 6" panel with the one DMX output connector, one DMX input (Pass Through) connector, one DMX pass through (Bypass) switch, and a label detailing the use of the pass through assembly.
2. The bypass switch shall be used when no DMX devices are present at that location. When activated, the DMX pass through switch shall pass DMX directly through to the next DMX panel on the strip. The pass through switch shall have a mechanical indicator to show the operator that it has or has not been engaged

I. Connector Strips shall be listed by a nationally recognized test lab (nrtl).

J. Physical

K. Connector strips shall be 6.25" H x 3.3" D and fabricated from 18-gauge galvanized steel and finished in black fine-texture powder coat paint.
   1. Covers shall be fabricated from 16-gauge galvanized steel

L. Connector strips shall be available in any length specified in increments of 6" and shipped fully wired with all splicing hardware.

M. Pigtails and outlets shall be spaced on 18" centers, or as otherwise specified.

N. Outlets shall be mounted on individual 3" panels and there shall be

O. No external terminal boxes shall be required for connector strips with 28 or fewer circuits unless otherwise specified.

P. Circuits shall be labeled on the connector strip with 2" lettering.
   1. Circuit labeling options shall include
      a. Circuits shall be labeled on the front side of the connector strip with white lettering on black background labels.
      b. Circuits shall be labeled on front and back sides of the connector strip with white lettering on black background labels.
      c. Circuits shall be labeled on the front side of the connector strip with engraved lamicoid labels utilizing white lettering on black background labels.
      d. Circuits shall be labeled on the front and rear sides of the connector strip with engraved lamicoid labels utilizing white lettering on black background labels.
      e. Circuits shall be labeled on one side of the connector strip using individual circuit cover plates with lettering engraved in the cover and filled with the specified color.
      f. Circuits shall be labeled using specified labeling per plans and drawings

Q. Connector strips shall support optional LED indicators to indicate the presence of power at each local circuit. The indicator shall be red in color and mounted in the connector strip
   1. The LED indicator shall be mounted in the lower right corner of the outlet panel
   2. The LED indicator shall be mounted in the connector strip trough directly below the outlet panel.
   3. The LED indicator shall be mounted in the center of the 3" plate directly below the circuit label for pigtail circuits

R. Junction Boxes
   1. Gridiron junction boxes shall be available to accommodate SO or SOW cable wiring into connector strips mounted to non-fixed locations
   2. Junction Boxes shall be fabricated from 16-gauge cold rolled steel with 14 gauge end panels. They shall be finished with fine-textured, scratch-resistant, black powder coat paint. Cover(s) shall be 16-gauge cold rolled steel and hinged to allow mounting in any direction.

## 1.10 N.COLOR MIXING LIGHT EMITTING DIODE PROFILE FIXTURE

A. General

B. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource Spot (INCLUDE Ellipsoidal bodies with beam spread as indicated, Fresnel Adapters and Cyc Adapters as indicated) as manufactured by Electronic Theatre Controls, Inc. or approved equal. Provide the following Accessories in quantities indicated below:
   1. Ellipsoidal Body with 26 Degree Lens and Shutters – 12
   2. Top Hat
   3. C-Clamp
   4. Safety Cable

C. Provide one 10’ power con extension cable and one 5 pin XLR DMX extension cable per Color Source fixture rather they be spots or pars.

D. All LED fixtures shall be provided by a single manufacturer to ensure compatibility.

E. The fixture shall be UL 1573 listed for stage and studio use.

F. The fixture shall comply with the USITT DMX-512A standard.

G. Physical

H. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits.

I. The following shall be provided:
   1. Lens secured with silicone shock mounts
   2. Shutter assembly shall allow for +/-25° rotation
   3. 20 gauge stainless steel shutters
   4. Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement
   5. Sturdy integral die cast gel frame holders with two accessory slots, and a top-mounted, quick release gel frame retainer
   6. Rugged steel yoke with two mounting positions allowing 300°+ rotation of the fixture within the yoke
   7. Positive locking, hand operated yoke clutch
   8. Slot with sliding cover for motorized pattern devices or optional iris

J. The housing shall have a rugged black powder coat finish
   1. White or silver/gray powder coat finishes shall be available as color options
   2. Other powder coat color options shall be available on request

K. Power supply, cooling and electronics shall be integral to each unit.

L. The unit shall ship with:
   1. Theatrical-style hanging yoke as standard
   2. 10’ cable with Neutrik PowerCon™ to choice of connector as standard
   3. Gate diffuser
   4. A-size pattern holder

M. Available options shall include but not be limited to:
   1. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
   2. PowerCon to PowerCon cables for fixture power linking

3. Smooth Wash Diffuser for overlapping beams of light from multiple fixtures

N. Optical

O. The light beam should have a 2-to-1 center-to-edge drop-off ratio

P. The unit shall provide, but not be limited to:
  1. Low gate and beam temperature
  2. Sharp imaging through a three-plane shutter design

Q. The unit shall provide, but not be limited to:
  1. 5, 10, 14, 19, 26, 36, 50, 70 and 90 degree field angles
  2. High-quality pattern imaging
  3. Sharp shutter cuts without halation
  4. Shutter warping and burnout in normal use shall be unacceptable
  5. Adjustable hard and soft beam edges

R. 19, 26, 36, and 50 degree units shall have optional lens tubes available for precision, high-contrast imaging.

S. Environmental and Agency Compliance

T. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.

U. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use

V. The fixture shall be rated for IP-20 dry location use.

W. Thermal

X. Fixture shall be equipped with a cooling fan.

Y. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 20,000 hours of use
  1. Thermal management shall include multiple temperature sensors within the housing to include:
    a. LED array circuit board temperatures
    b. Fixture ambient internal temperature

Z. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

AA. Electrical

BB. The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply

CC. The fixture shall support power in and thru operation
  1. Power in shall be via Neutrik® PowerCon™ input connector
  2. Power thru shall be via Neutrik ® PowerCon ™ output connector

3. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker

DD. The fixture requires power from a non-dim source

EE. Fixtures shall have droop compensation to prevent thermal shift of color or intensity

FF. Power supply outputs shall have self-resetting current-limiting protection

GG. Power supply shall have power factor correction

HH. LED Emitters

II. The fixture shall contain a minimum of four different LED colors to provide color characteristics as described in the Color Section below.

JJ. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.

KK. Fixture shall utilize Luxeon® Rebel™ LED emitters

LL. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.

MM. LED emitters should be rated for nominal 20,000-hour LED life to 70% intensity

NN. All LED fixtures (100% of each lot) shall undergo a minimum three-hour burn-in test during manufacturing.

OO. LED system shall comply with all relevant patents

PP. Calibration

QQ. Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
1. Calibration data shall be stored on the control card as a permanent part of on-board operating system
2. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
3. Fixtures not offering LED calibration shall not be acceptable

RR. Color

SS. The fixture shall utilize a minimum of 60 LED emitters

TT. The fixture shall utilize a selective mix of Red, Green, Blue and Lime emmitters

UU. Dimming
1. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
2. The fixture shall utilize a Incandescent dimming curve
3. Dimming curve shall be optimized for smooth dimming over longer timed fades.

4. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
5. LED control shall be compatible with broadcast equipment in the following ways:
    a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    b. PWM shall be capable of being set via RDM to 25,000hz

VV. Control and User interface
1. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors or RJ45 connectors
2. The fixture shall be compatible with the ANSI RDM E1.20 standard
    a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
3. The fixture shall be equipped with a 7-segment display
4. The fixture shall be equipped with a three-button user-interface
5. The fixture shall be controlled via RGB data input

WW. 5-channel footprint (IRGBS)
1. A variable-rate strobe channel shall be provided
2. The fixture shall offer stand-alone functionality eliminating the need for a console
    a. Fixture shall ship with 12 preset colors accessible as a stand-alone feature
    b. Fixture shall ship with 5 sequences accessible as a stand-alone feature
    c. Each color and sequence can be modified by the end user via RDM
    d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
    e. Up to 32 fixtures may be linked
    f. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming
    g. Fixtures without stand-alone operation features described above shall not be acceptable.

1.11 DATA PLUG-IN STATIONS

A. General
1. The Plug-in Stations shall consist of the appropriate connectors required for the functional intent of the system. These stations shall be available with DMX input or output, Remote Focus Unit, Network, or architectural control connectors. Custom control connectors shall be available.
2. The following standard components shall be available for Plug-in Stations:
    a. 5-Pin male XLR connectors for DMX input
    b. 5-Pin female XLR connectors for DMX output
    c. 6-Pin female XLR connectors for RFU and ETCLink connections
    d. RJ45 connectors for Network connections - Twisted Pair
    e. 6-Pin female DIN connectors for Unison connections
    f. DB9 female serial connector for architectural control from a computer
3. Custom combinations and custom control connections shall be available.
4. Physical

5. Station faceplates shall be .80" aluminum, finished in fine texture, scratch-resistant black powder coat. Silk-screened graphics shall be white.
6. The station panel shall mount into an industry standard back box, depending on size and quantity of connectors. A terminal block shall be supplied for contractor terminations.

## 1.12 INSTALLATION

A. It shall be the responsibility of the Electrical Contractor to receive and store the necessary materials and equipment for installation of the dimmer system. It is the intent of these specifications and plans to include everything required for proper and complete installation and operation of the dimming system, even though every item may not be specifically mentioned. The contractor shall deliver on a timely basis to other trades any equipment that must be installed

B. The electrical contractor shall be responsible for field measurements and coordinating physical size of all equipment with the architectural requirements of the spaces into which they are to be installed.

C. The electrical contractor shall install all lighting control and dimming equipment in accordance with manufacturers approved shop drawings.

D. All branch load circuits shall be live tested before connecting the loads to the dimmer system load terminals.

E. Contractor shall include time to meet with the owner to determine and configure touch panel control preferences. It shall also include a person to be on site 4 weeks after project completion to make any adjustments per owner’s request.

## 1.13 MANUFACTURER'S SERVICES

A. Upon completion of the installation, including testing of load circuits, the contractor shall notify the dimming system manufacturer that the system is available for formal checkout.

B. Notification shall be provided in writing, two weeks prior to the time that factory-trained personnel are needed on the job site.

C. No power is to be applied to the dimming system unless specifically authorized by written instructions from the manufacturer.

D. The purchaser shall be liable for any return visits by the factory engineer as a result of incomplete or incorrect wiring.

E. 5. Upon completion of the formal check-out, the factory engineer shall demonstrate operation and maintenance of the system to the owner’s representatives. Training shall not exceed four working hours. Additional training shall be available upon request.

## 1.14 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two years from date of delivery.

B. Warranty shall cover repair or replacement of such parts determined defective upon inspection.

C. Warranty does not cover any product or part of a product subject to accident, negligence, alteration, abuse or misuse. Warranty does not cover any accessories or parts not supplied by the manufacturer.

D. Warranty shall not cover any labor expended or materials used to repair any equipment without manufacturers prior written authorization.

**END OF SECTION 26 09 61**

# SECTION 261219 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

B. Products Installed, but Not Furnished, under This Section:

1. The transformer serving the Art Annex has been purchased by the Owner. Installation is the responsibility of the contractor

C. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 013100 "Project Management and Coordination" for preinstallation conference procedures.

### 1.2 DEFINITIONS

A. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

B. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."

C. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).

D. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).

E. Elbow Connector: See "bushing elbow" above.

## 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

# PART 2 - PRODUCTS

## 2.1 OWNER-FURNISHED PRODUCTS

A. Description: The Owner has elected to pre-purchase the transformer serving the Art Annex.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on line- or load-side bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.

5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of the same length to balance and distribute weight when handling transformers with crane.
8. Use spreaders or lifting beam to obtain vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting discrepancies or adverse conditions. Verify that effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:

1. Verify removal of shipping bracing after placement.
2. Remove sample of insulating liquid in accordance with ASTM D923. Insulating-liquid values must comply with NETA ATS, Table 100.4. Sample must be tested for the following:

   a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
   b. Acid Neutralization Number: ASTM D974.
   c. Interfacial Tension: ASTM D971.
   d. Color: ASTM D1500.

e. Visual Condition: ASTM D1524.

H. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at transformer location.

I. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION

A. Install transformers on cast-in-place concrete equipment base(s).

B. Transformer must be installed level and plumb and must tilt less than 1.5 degrees while energized.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's published instructions and IEEE C2.

## 3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than 4/0 AWG, buried not less than 30 inch below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
2. Fence and equipment connections may not be smaller than 4 AWG. Ground fence at gate posts and corner posts and at intervals not exceeding 10 ft . Bond gate sections to fence posts using 1/8 by 1 inch flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate grounding and bonding conductors on common equipment grounding terminal on transformer enclosure.
5. Complete transformer tank grounding and lightning arrester connections prior to making other electrical connections.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that

could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of transformers in accordance with Section 260513 "Medium-Voltage Cables."

## 3.4 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

## 3.5 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Owner.

B. Tests and Inspections:

1. General Field-Testing Requirements:

   a. Comply with provisions of "Testing and Test Methods" Chapter in NFPA 70B.
   b. Perform visual and mechanical inspections and electrical tests. Certify compliance with test parameters.
   c. After installing transformer but before primary is energized, verify that grounding system at transformer is tested at specified value or less.
   d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
   e. Visual and Mechanical Inspection:

      1) Verify equipment nameplate data complies with Contract Documents.
      2) Inspect bolted electrical connections for high resistance using one of the following two methods:

         a) Use low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

2. Liquid-Filled Transformer Field Tests:

   a. Visual and Mechanical Inspection:
      1) Inspect anchorage, alignment, and grounding.
      2) Verify bushings are clean.

3) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
4) Verify that liquid level in tanks is within manufacturer's published tolerances.
5) Perform specific inspections and mechanical tests recommended by manufacturer.
6) Verify presence of transformer surge arresters and that their ratings are as specified.
7) Verify that as-left tap connections are as specified.

b. Electrical Tests:
1) Measure core insulation resistance at 500 V(dc) if core is insulated and core ground strap is removable. Core insulation-resistance values may not be less than 1 MΩ at 500 V(dc).
2) Perform turns-ratio tests at all tap positions. Turns-ratio test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
3) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
4) Remove sample of insulating liquid in accordance with ASTM D923, and perform dissolved-gas analysis in accordance with IEEE C57.104 or ASTM D3612.

C. Nonconforming Work:

1. Equipment and devices will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest.

D. Prepare test and inspection reports. Record as-left set points of adjustable devices.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

## 3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at outgoing section of transformers. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

a. Adjust transformer taps.

b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
4. Report:

a. Prepare written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting minimum temperature difference of 1 deg C at 30 deg C.
3. Record of Infrared Inspection: Prepare certified report that identifies testing technician and equipment used, and lists results as follows:

a. Description of equipment to be tested.
b. Discrepancies.
c. Temperature difference between area of concern and reference area.
d. Probable cause of temperature difference.
e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
f. Identify load conditions at time of inspection.
g. Provide photographs and thermograms of deficient area.

4. Act on inspection results in accordance with recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

**END OF SECTION 261219**

# SECTION 26 13 00 – MEDIUM-VOLTAGE SWITCHGEAR

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Owner-furnished, Contractor-installed switchgear

### 1.2 ACTION SUBMITTALS

A. None required.

### 1.3 INFORMATIONAL SUBMITTALS

A. None required.

### 1.4 CLOSEOUT SUBMITTALS

A. None required.

## PART 2 - PRODUCTS

### 2.1 Switchgear is owner-furnished, contractor-installed

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Handling:

1. Handle switchgear, in accordance with manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
3. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
4. Do not damage structure when handling switchgear.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders have to cross section barriers to reach load or line lugs.

C. Pre-Installation Checks:
   1. Verify removal of shipping bracing after placement.

D. Adjust 5-ohm value in first paragraph below to suit Project conditions.

E. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 ohms at switchgear location.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 SWITCHGEAR INSTALLATION

A. Equipment Mounting:
   1. Install switchgear on cast-in-place concrete equipment vaults.
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Install level and plumb, tilting less than 1.5 degrees when energized.

C. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and NFPA 70.

D. Maintain minimum clearances and workspace at equipment in accordance with manufacturer's instructions and IEEE C2.

## 3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

   1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inch (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
   2. Fence and equipment connections must not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3 m). Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) flexible braided copper strap and clamps.
   3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
   4. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure.

5. Complete the switchgear grounding and surge protector connections prior to making other electrical connections.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within the switchgear enclosure. Arrange conductors such that there is not excessive strain on the connections that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of switchgear in accordance with Section 260513 "Medium-Voltage Cables."

D. Medium Voltage Switchgear Tests

1. Visual and Mechanical Inspection:

a. Verify that current and voltage transformer ratios correspond to Drawings.
b. Inspect bolted electrical connections using calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
c. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

d. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit breaker ratings match Drawings.

2. Electrical Tests:

a. Inspect bolted electrical connections using a low-resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. If manufacturer has no recommendation for this test, it must be conducted in accordance with NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential must be 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable. Test duration must be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring must not be less than 2 megohms.

e. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

f. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

g. Perform system function tests in accordance with "System Function Tests" Article.

E. Medium-Voltage Vacuum Interrupter Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.

c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism in accordance with manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism must be in accordance with manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
k. Perform time-travel analysis. Travel and velocity values must be in accordance with manufacturer's published data.
l. Record as-found and as-left operation counter reading. Operation counter must advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values must be in accordance with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests must not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values must not exceed the high levels of the normal range in accordance with manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the trip and close coils must comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features must operate in accordance with manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.
f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values must comply with manufacturer's published data.

g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the specimen is considered to have passed the test.

h. Perform a dielectric-withstand-voltage test in accordance with manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the specimen is considered to have passed the test.

3.4 FOLLOW-UP SERVICE

A. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove necessary covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 86 deg F (30 deg C).
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the results as follows:

   a. Description of equipment to be tested.
   b. Discrepancies.
   c. Temperature difference between the area of concern and the reference area.
   d. Probable cause of temperature difference.
   e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
   f. Identify load conditions at time of inspection.
   g. Provide photographs and thermograms of the deficient area.

4. Act on inspection results in accordance with the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

**END OF SECTION 26 13 00**

# SECTION 26 22 13 – LOW-VOLTAGE DRY-TYPE TRANSFORMERS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. 600 volts and below dry-type transformers

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Enclosure dimensions
   2. KVA rating
   3. Primary and secondary nominal voltages
   4. Voltage taps
   5. Weight
   6. Insulation class
   7. Temperature rise
   8. Core and coil materials
   9. Impedances
   10. Audible noise level
   11. Inrush data

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Schneider Electric

B. General Electric by ABB

C. Hevi Duty, Siemens

D. Eaton Cutler-Hammer.

## 2.3 DRY-TYPE TRANSFORMERS

A. Three phase transformers shall have a delta primary (unless noted otherwise on the drawings) and a secondary as noted on the drawings. Transformer shall have a minimum of (4) 2-1/2% full current below normal and (2) 2-1/2% full current above normal taps. For < 350V, transformer shall have a minimum of (2) 5% full current below normal and (1) 5% full current above normal taps.

B. Transformers shall be ANSI Class AA (Self-Cooled), as defined by ANSI-C57.12.01 and have at least a Class 155 insulation. Transformers shall be 115°C-temperature rise above 40°C ambient. 115°C rise transformers shall be capable of carrying a 15% continuous overload without exceeding a 150°C rise in a 40°C ambient. All insulating materials to be in accordance with NEMA ST20 2014 standards for a 220°C UL component recognized insulation system.

C. Transformer efficiency shall be in accordance with the latest version of DOE 10 CFR 431.196.

D. Provide copper windings.

E. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.

F. Provide a 4”wide x 1½” high phenolic nameplate reading the following for each transformer:

| | |
|---|---|
| __kVA TRANSFORMER IDENTIFICATION | (3/8” Lettering) |
| FEEDS LOAD NAME | (3/8” Lettering) |
| FED FROM SOURCE NAME | (1/4” Lettering) |

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions and seismic requirements applicable to Project.

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Secure transformer to concrete base in accordance with manufacturer's published instructions.

D. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

F. Tops of transformers shall be marked to prohibit storage on transformers.

3.2 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.3 MAINTENANCE

A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.

1. Use infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and another at 11 months after Substantial Completion.
3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

**END OF SECTION 26 22 13**

# SECTION 26 24 13 – SWITCHBOARDS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Main switchboard
2. Distribution switchboards

### 1.2 ACTION SUBMITTALS

A. Product Data

1. Switchboards.
2. Overcurrent protective devices.
3. Surge protection devices.
4. Groud-fault protection devices.
5. Accessories.
6. Other components.
7. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than UL 50E, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

2.2 MANUFACTURERS

A. Schneider Electric

B. General Electric by ABB

C. Siemens

D. Eaton Cutler Hammer.

2.3 GENERAL

A. Switchboards shall be furnished and installed as shown on the drawings and specified below.

B. The switchboards shall be dead front with front accessibility only in NEMA 1 enclosure.

C. The switchboards' bussing shall be plated copper sized in accordance with UL 891 and have a minimum short circuit rating as noted on the drawings.

D. Neutral bus shall be 100% rated.

E. All protective devices installed in the Switchboard shall have a kAIC rating to match the switchboard kAIC rating unless otherwise noted.

F. Provide 6" wide x 2" high phenolic switchboard nameplates reading the following:

| | |
|---|---|
| **SWITCHBOARD _______** | **(5/8" Lettering)** |
| **___/___V __PH __W ____A** | **(3/8" Lettering)** |
| **____kAIC FULLY RATED** | **(3/8" Lettering)** |
| **FED FROM ____________** | **(3/8" Lettering)** |

G. Provide labeling indicating Available Fault Current with calculation date Per NEC 2020 408.6.

H. Fusible switches or circuit breakers shall be provided in the sizes and arrangements shown on the drawings. Provide a 3" wide x 1" high phenolic nameplate for each switch/breaker as follows:

| | | |
|---|---|---|
| **EQUIPMENT IDENTIFICATION** | | **(3/8" Lettering)** |
| **__AS/__AF** | **(XX AMP FRAME/XX AMP TRIP)** | **(1/4" Lettering)** |

I. Digital metering shall be as specified in 26 27 13.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide housekeeping pads for floor mounted switchboards.

B. Equipment Mounting: Install switchboards on concrete base, 4 inch nominal thickness. Comply with requirements for concrete base specified in Section 260529 "Hangers and Supports for Electrical Systems."
   1. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of concrete base.
   3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to switchboards.
   6. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Retain first subparagraph below if seismic controls are required for Project. Coordinate with Drawings. Where seismic mounting is required, bottom conduit entry is preferred.

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Operating Instructions: Frame and mount printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

G. Install filler plates in unused spaces of panel-mounted sections.

H. Install overcurrent protective devices, surge protection devices, and instrumentation.

I. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.

J. Support and secure conductors within switchboard in accordance with NFPA 70.

K. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Owner.

B. Tests and Inspections:

1. Acceptance Testing:

a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment in accordance with NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

**END OF SECTION 26 24 13**

# SECTION 26 24 16 – PANELBOARDS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Distribution panelboards
   2. Circuit breaker panelboards

### 1.2 ACTION SUBMITTALS

A. Product Data

B. Shop Drawings

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual

### 1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Two (2) keys for each type of panelboard.

B. One (1) spare breaker for each type of breaker (GFCI, standard, etc.).

### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Schneider Electric

B. General Electric by ABB

C. Siemens

D. Eaton Cutler Hammer.

## 2.3 DISTRIBUTION PANELBOARDS

A. Panelboards shall be installed as shown on the drawings and specified below.

B. Panels shall be dead front type, with fusible switches or circuit breakers furnished in sizes as indicated on drawings.

C. The panels shall include an equipment grounding bus.

D. Main buses and connectors shall be copper of sufficient current carrying capacity to limit the temperature rise to 65KC per UL tests and have a minimum short circuit rating of 10,000A (120/208V) or 14,000A (277/480V) or as noted on the drawings.

E. All protective devices shall be bolt-on type.

F. All protective devices installed in the distribution panelboard shall have a kAIC rating to match the distribution panelboard kAIC rating unless otherwise noted.

G. All main bus joints, tap connections, and contact points shall be silver or tin-plated.

H. Provide a 6" wide x 2" high phenolic panelboard nameplate reading the following:

| | |
|---|---|
| **PANELBOARD IDENTIFICATION** | **(5/8" Lettering)** |
| **___V __Ph __W ____ A** | **(3/8" Lettering)** |
| **__kAIC FULLY RATED** | **(3/8" Lettering)** |
| **FED FROM _____** | **(3/8" Lettering)** |

I. Provide labeling indicating Available Fault Current with calculation date Per NEC 2020 408.6.

J. Fusible Switches and Circuit Breakers: Fusible switches and circuit breakers shall be provided in the sizes and arrangements shown on the drawings. Fusible switches shall accept Class R fuses.

K. Provide a 3" wide x 1" high phenolic nameplate for each switch as follows:

| | |
|---|---|
| **EQUIPMENT IDENTIFICATION** | **(3/8" Lettering)** |
| **__AS/__AF (XX AMPS WITH/XX AMP FUSE)** | **(1/4" Lettering)** |

L. The switches shall be provided with a door interlock to prevent access to fuses and switch when energized and manually operated interlock defeat mechanism. The door is to be furnished with "on off" handle position markings and a means to lock the switch in the open position is to be provided.

## 2.4 ELECTRICALLY CONTROLLED PANELBOARDS

A. PANELBOARDS

1. Panelboard shall be equipped with a Master Controller to allow for programming and operation of the electronically controlled breakers.
2. Intelligent panelboards shall use standard boxes, interiors, and trims. Panelboard shall not require different construction to accommodate control components. All control components shall install onto standard panelboard interiors. Control components shall not restrict field wiring in gutter space.
3. All intelligent panelboards shall be provided with remotely operated circuit breakers and intelligent control bus providing interface to remotely operable circuit breakers. Panelboards shall accept a mix of standard and remotely operated circuit breakers.
4. The intelligent panelboard system shall fully accommodate the separation of Class 1 and Class 2 control circuits as required by the NEC. The control bus shall be a UL-listed Class 1 control device for installation in the same panelboard gutter with field-installed power circuits. Intelligent panelboards using control bus devices that are not specifically listed as UL Class 1 shall be provided with physical barriers to completely separate field wiring from the control bus, circuit breaker connections, and all associated Class 2 wiring.
5. System Power Supply: The system power supply shall mount on the panelboard interior and be fed directly from the panelboard bus without external wiring or fuses. The power supply shall provide isolated Class 1 and Class 2 sources to allow field wiring to meet NEC requirements. Each power supply shall provide capacity for 8 control busses with 168 circuit breakers in up to 8 panelboards, and one controller.

B. REMOTELY OPERATED CIRCUIT BREAKERS

1. Remotely operated branch circuit breakers shall provide overload and short circuit protection suitable for the location in the electrical system, as defined in the panelboard schedules. Remotely operated power switching devices shall have the following:
    a. Integral branch circuit overcurrent protection as required by the NEC. Circuit breakers shall have a UL-listed interrupting rating sufficient for the application or UL-listed series connected ratings for the maximum available fault current at that point in the system. Submittals reflecting the use of relays or contactors to perform remote switching shall show evidence in writing that the relays or contactors are listed to withstand the available fault current.
    b. UL-listed SWD ratings for 15 ampere, 20 ampere, and 30 ampere 1-pole, 2-pole, and 3-pole branch devices, HID ratings, and HACR ratings.
    c. Handle operator that shall mechanically open the power switching device contacts when moved to the OFF position and disable the contacts from being remotely closed. Handle operator shall accept field-installable handle tie to allow application where a handle tie is required by the NEC.
    d. Manual override switch to enable or disable the remote operation of the device and allow circuit breaker handle to fully control the on/off state of the circuit breaker. Override shall fully disengage remote operation of the circuit breaker mechanism. Device utilizing one-shot or temporary overrides shall not be accepted.
    e. Visible flag that clearly indicates the status of the circuit breaker contacts with the panel trim installed. Flag shall indicate ON, OFF, and TRIPPED circuit breaker states. The visible flag shall be mechanical in nature, directly tied to the circuit breaker mechanism, and shall be provided in addition to any status indicator supplied by the system electronics.
    f. Voltage status signal to indicate the presence or absence of voltage at the load terminal as a true indication of the on/off status of the connected circuit to aid in identifying wiring errors, such as a back-feed or disconnected neutral conductor.
    g. Circuit to indicate the number of poles of the remotely operable circuit breaker.

h. Integral control connector to simplify and speed installation and eliminate wiring errors such that the control connection is made automatically when installing the breaker in the panelboard. Connection to the breaker shall not introduce control wiring into the panelboard gutter space. Control connections shall be rated NEC Class 1 to eliminate the requirement for barriers in the gutter space such that control connections may reside with electrical power circuit conductors.

i. Switching full load endurance rating of 200,000 open/close/open remote operations. Switching devices with lower ratings or no published ratings may be judged to be acceptable, but shall be provided with 100% spare switching devices for each circuit to ensure an equivalent total number of operations.

## 2.5 CIRCUIT BREAKER PANELBOARDS

A. Panels shall be dead front, safety type, furnished with branch circuit protecting devices, equipment grounding bus, phenolic nameplate, main bus and cable lugs factory assembled, with all components in place, ready for installation. Contractor to determine top or bottom feed for lug placement. Feed locations shall not be reviewed by the Engineer.

B. The circuit breakers shall be of the molded case, bolt on type suitable for voltage and ampere ratings indicated on drawings and in schedules and shall have a minimum interrupting capacity of 10,000 amperes (120/208V) or 14,000 amperes (277/480V) or as noted on the drawings.

C. Provide lockable red circuit breakers on all circuits serving the fire alarm system.

D. Buses and connectors shall be silver or tin plated hard drawn copper of 98% conductivity, with current carrying capacity to maintain established rise tests as defined in UL Standard UL 67.

E. A directory frame shall be attached to inside face of hinged door. The directory card shall be neatly typed to identify circuits. A transparent plastic facing shall protect the directory card. Room numbers shall be included in directory descriptions. Furnish a copy of each panel directory to the Architect/Engineer. Where existing panelboard loads are modified, the panel directories shall be updated.

F. Provide labeling indicating Available Fault Current with calculation date Per NEC 2020 408.6.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Provide housekeeping pads for floor mounted panelboards.

B. All flush mounted panelboards shall have four (4) spare 1” conduits stubbed up out of the panelboard and extended to above an accessible ceiling. Panelboards in interior walls shall have two conduits stubbed out on both sides of the wall (four conduits total). Panelboards in exterior walls shall have three conduits stubbed out into the building interior.

C. Create a directory to indicate loads served by each circuit; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are unacceptable.

## 3.2 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Field tests and inspections must be witnessed by Owner.

C. Tests and Inspections:
   1. Retain first and second options in first subparagraph below if panelboards with factory-installed SPD are specified.
   2. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Certify compliance with test parameters.
   3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
      a. Perform the following infrared scan tests and inspections and prepare reports:
      b. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      c. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      d. Instruments and Equipment:
         1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

## 3.3 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's instructions.
   2. Confirm correct communication wiring, initiate communications between panels, and program control system according to approved time-of-day schedules and input override assignments.

## 3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 MAINTENANCE

A. Software and Firmware Service Agreement:
   1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
   2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.
      a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
   3. Upgrade Reports: Prepare written report after each update, documenting upgrades installed.

**END OF SECTION 26 24 16**

# SECTION 26 27 13 – METERING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Main switchboard metering

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual

### 1.4 CLOSEOUT SUBMITTALS

A. Operation Manual

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Schneider Electric/Square D PowerLogic PM5560 or equivalent

### 2.3 METERS

A. The monitors shall have the ability to display real-time voltage, current, real power, reactive power, apparent power, power factor, and frequency. The meter shall also be capable of alarming, logging, and waveform capture based upon setup values and limits.

B. Provide CT's and all power connections as required.

C. Remote Reading Requirements:
   1. TCP/IP adapter

2. USB interface
3. BACnet IP
4. Modbus TCP/IP

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Factory installed.

### 3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Owner.

B. Tests and Inspections:

1. Equipment and Software Setup:

    a. Set meter date and time clock.
    b. Test, calibrate, and connect pulse metering system.
    c. Set and verify billing demand interval for demand meters.
    d. Report settings and calibration results.
    e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.

2. Connect load of known power rating, 1 kW minimum, to circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from meter reading tests.

C. Nonconforming Work:

1. Electricity metering will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Collect, assemble, and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

**END OF SECTION 26 27 13**

# SECTION 262726 - WIRING DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Hospital-grade straight-blade receptacles.
5. Receptacles with arc-fault and ground-fault protective devices.
6. Locking receptacles.
7. Pin-and-sleeve receptacles.
8. Special-purpose power outlet assemblies.
9. Connectors, cords, and plugs.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
3. Section 262726.11 "General-Use Switches, Dimmer Switches, and Fan-Speed Controller Switches" for additional wiring device products.
4. Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" for additional wiring device products.
5. Section 262726.37 "Receptacles with Arc-Fault and Ground-Fault Protective Devices" for additional wiring device products.
6. Section 262726.39 "Locking Receptacles" for additional wiring device products.
7. Section 262726.43 "Special-Purpose Power Outlet Assemblies" for additional wiring device products.

### 1.2 DEFINITIONS

A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.

### 1.3 ACTION SUBMITTALS

A. Product Data:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Receptacles with arc-fault and ground-fault protective devices.
5. Locking receptacles.
6. Pin-and-sleeve receptacles.
7. Special-purpose power outlet assemblies.
8. Connectors, cords, and plugs.

B. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

1.4 CLOSEOUT SUBMITTALS

A. Operating Instructions: For each type of product.

PART 2 - PRODUCTS

2.1 DEVICES:

| Receptacles | Hubbell | Leviton | P & S |
|---|---|---|---|
| 20A Duplex | HBL5362 | 5362A | 5362A-I |
| 20A GFI | GF20L | 7899 | 2095-I |
| 20A Duplex w/ USB | USB20ACW | T5833 | TR20USBAC6W |

| Switches | Hubbell | Leviton | P & S |
|---|---|---|---|
| 20A Single | 1221 | 1221-2 | PS20ACI |
| 20A 3-way | 1223 | 1223-2 | PS20AC3 |
| 20A 4-way | 1224 | 1224-2 | PS20AC4 |
| 20A 2 pole | 1222 | 1222-2 | PS20AC2 |

| Nylon Plates | Hubbell | Leviton | P & S |
|---|---|---|---|
| Duplex | NP8 | 80703 | TP8 |
| Quadplex | NP82 | 80716 | TP82 |
| Single Toggle | NP1 | 80701 | TP1 |
| 2-Gang Toggle | NP2 | 80709 | TP2 |
| GFI | NP26 | 80401-N1 | TP26 |

2.2 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

A. Toggle Switch:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN WMUZ and UL 20.

3. Options:

a. Device Color: As indicated on architectural Drawings.

4. Accessories:

a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

A. Single Straight-Blade Receptacle:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

3. Options:

a. Device Color: As indicated on architectural Drawings.

4. Accessories:

a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

3. Options:

a. Device Color: As indicated on architectural Drawings.

4. Accessories:

a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES

A. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:

1. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.

3. Options:

a. Device Color: As indicated on architectural Drawings.

4. Accessories:

a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

## 2.6 LOCKING RECEPTACLES

A. NEMA, 125 V, Locking Receptacle <Insert drawing designation>:

1. Regulatory Requirements:

   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

   a. Reference Standards: UL CCN RTRT and UL 498.

3. Options:

   a. Device Color: Black with yellow voltage indication on face.
   b. Configuration: 2 pole, 3 wire, grounding, as required for equipment.

B. NEMA, 250 V, Locking Receptacle <Insert drawing designation>:

1. Regulatory Requirements:

   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. General Characteristics:

   a. Reference Standards: UL CCN RTRT and UL 498.

3. Options:

   a. Device Color: Black with blue voltage indication on face.
   b. Configuration: As required for equipment.

## 2.7 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Power Outlet Cord Management Assembly:

1. Source Limitations: Obtain all components for each power outlet cord management assembly from single manufacturer.
2. Regulatory Requirements: Components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics: Provide the following specified products with fabricated power outlet cord management assembly:

   a. Cord Management System:

1) Spring-driven commercial/industrial-use cord reel, 12AWG conductors.

b. Termination Fitting:
   1) Outdoor-use, watertight, sealed cord connector.

4. Options:

   a. Mounting: Ceiling.

B. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. General Characteristics:

   a. Reference Standards: UL CCN SBCV and UL 355.
   b. Spring take-up retraction mechanism.

3. Options:

   a. Electrical Rating with Cable: 600 V, 25 A.
   b. Color: Yellow.
   c. Enclosure Degree of Protection: Type 4.
   d. Ball stop.
   e. Pivot base.
   f. Spool Capacity:

      1) No. 12 AWG, two wires and equipment ground, 30 ft (9.1 m).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

D. Interfaces with Other Work:

1. Coordinate installation of new products with existing conditions.

## 3.3 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number.

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

D. Interfaces with Other Work:

1. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.

## 3.4 INSTALLATION OF CORD REELS AND FITTINGS

A. Comply with manufacturer's instructions.

B. Interfaces with Other Work:

1. Coordinate installation of new products with existing conditions.

## 3.5 FIELD QUALITY CONTROL OF SWITCHES

A. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.

B. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

## 3.6 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

## 3.7 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.

3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

3.8 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

A. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's instructions.

B. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.9 ADJUSTING

A. Cord Reels and Fittings: Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

3.10 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

B. Cord Reels and Fittings:

1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

C. Connectors, Cords, and Plugs:

1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

**END OF SECTION 262726**

# SECTION 26 28 13 – FUSES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Fuses

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Bussmann

B. Mersen

### 2.3 FUSES

A. Electrical Contractor shall furnish and install a complete set of fuses as manufactured by the Bussmann Company or Mersen Electrical Power (Ferraz Shawmut), sized for ordinary service of motors and other loads served and at each safety switch installed as shown on the drawings and as hereinafter specified.

B. Fuses for motor loads and all other loads up to 600 A and up to 600 V shall be Buss “Low Peak” or Mersen Amptrap 2000 dual element fuses, having a minimum interrupting capacity of 200,000 A RMS symmetrical. The fuses shall be UL Class RK1.

C. Fuses for all loads above 600 A and up to 600 V shall be Buss “Low Peak” or Ferraz Mersen Amptrap 2000 current limiting, time delay fuses, with a minimum interrupting capacity of 200,000 A RMS symmetrical. The fuses shall be UL Class L.

D. The installation of fuses of mixed manufacturers shall not be accepted. Fuse of only one manufacturer shall be installed.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Upon completion of the building construction, the Contractor shall provide a complete set of three spare fuses for each size and type used.

**END OF SECTION 26 27 13**

# SECTION 26 28 16 – DISCONNECT SWITCHES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Disconnect Switches

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Siemens

B. Schneider Electric

C. Eaton Cutler Hammer

D. General Electric by ABB

### 2.3 DISCONNECT SWITCHES

A. Type of Switch: Furnish and install disconnect switches as specified where shown on the drawings.

B. All disconnect switches shall be classed Heavy Duty and enclosed as required by NEMA Standards. Switch sizes and fusing shall be as shown on the drawings.

C. Switch shall have a quick make, quick break mechanism operating through the box and not the cover. The switchblades shall be visible when the hinged door is open.

D. All disconnect switches on the secondary side of a VFD shall be equipped with an auxiliary contact kits with two (2) NO/NC form C contacts to activate before switch blades open. Contacts shall be rated as required for approved VFDs.

E. The cover shall be interlocked with the operating handle to prevent opening door when switch is "ON" and a means provided to lock switch in the "OFF" position. This mechanism shall be capable of being defeated.

F. Provide a 4" wide x 1½" high phenolic nameplate reading the following for each switch:

| | |
|---|---|
| **'EQUIPMENT IDENTIFICATION'** | **(3/8" Lettering)** |
| **SERVICE DISCONNECT** | **(3/8" Lettering)** |
| **FED FROM 'SOURCE NAME'** | **(1/4" Lettering)** |
| **LOCATE IN 'SOURCE LOCATION'** | **(1/4" Lettering)** |

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install nameplates as described above.

B. Comply with manufacturer's published instructions.

C. Special Techniques:
1. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in fusible devices.

### 3.2 SELECTION OF ENCLOSURES

A. Indoor, Dry and Clean Locations: UL 50E, Type 1

B. Outdoor Locations: UL 50E, Type 3R.

C. Other Wet or Damp, Indoor Locations: UL 50E, Type 4.

3.3 MAINTENANCE

A. Infrared Scanning of Enclosed Switches and Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.

1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of enclosed switches and breakers, one at four months and another at 11 months after Substantial Completion.
3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
4. Report: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

**END OF SECTION 26 27 13**

# SECTION 26 28 19 – ELEVATOR POWER MODULE SWITCH

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Elevator power module switches

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Operation manual

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Bussmann Power Module Switch

B. Mersen

C. Eaton Cutler Hammer

### 2.3 ELEVATOR POWER MODULE SWITCHES

A. Power for the elevator shall be provided as indicated on the plans. The electrical contractor shall furnish and install conduit and wire to extend the feeder from the elevator equipment disconnect in the elevator room to the terminal lugs on the elevator equipment.

B. The elevator motor disconnect shall be a fused Bussmann Power Module Switch (or equivalent by Mersen or Eaton Cutler Hammer) with a shunt trip. The switch shall include a 120 volt control power transformer, fire safety interface relay with 120 volt coil, key test switch, green “on” pilot light, and shunt trip voltage monitoring relay.

C. The switch shall also include a mechanical interlock-auxiliary contact wired to disconnect the battery-operated car lowering device when the switch is manually opened. The auxiliary contact shall remain closed when the switch is tripped.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. The fire alarm safety relay shall be interlocked with the fire alarm system to shunt trip the switch upon alarm of any of the elevator hoist way or elevator equipment room heat detectors. The key test switch will simulate this alarm condition.

B. The heat detectors shall be located within two feet of each sprinkler head.

C. The exact location of all elevator devices shall be coordinated with the elevator manufacturer.

**END OF SECTION 26 27 19**

# SECTION 26 29 13 – MOTOR AND APPLIANCE CONTROL

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Magnetic motor starters
   2. Manual motor starters
   3. Selector switches and pushbuttons
   4. Relays
   5. Control devices
   6. Interconnection wiring

B. Electrical Contractor shall furnish and install all electrical devices incident to the work except as otherwise stated herein. The Mechanical Contractor will furnish prewired control panels for equipment so indicated on the plans and will furnish EP switches, electrical thermostats, pressure switches and other temperature control devices as required by the specific sequence of operation for installation by the Electrical Contractor. Others will do testing and adjusting of mechanical system devices.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual: For each type of product.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product.

B. Parts List: For each type of product that has replaceable parts.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Schneider Electric / Square D

B. Eaton Cutler Hammer

C. Allen Bradley

D. Siemens

E. General Electric

F. ABB

## 2.3 MOTOR AND APPLIANCE CONTROL

A. The motor and appliance control devices shall be as follows:

1. All starters shall be installed in NEMA 1 Enclosure unless noted otherwise on the drawings. Where noted other than NEMA 1, furnish the indicated NEMA rated enclosure.

2. Single Phase Magnetic Starters Square D Class 8536 with one overload, 120 volt coil, N.O. auxiliary contacts, heavy-duty 30 mm and hand off automatic selector switch in cover all in an oversized NEMA enclosure.

3. Three Phase Manual Starters Square D Class 2510 Type M, push button operated, lock-out guard, three thermal overloads in a NEMA enclosure. Furnish with or without pilot light and auxiliary contacts as indicated on drawings.

4. Three Phase Magnetic Starters Square D Class 8536 with three overloads, 120 volt control transformer with 2 primary and 1 secondary fuses, heavy-duty 30 mm, hand off automatic selector switch, heavy-duty 30 mm pilot light, and extra N.O. auxiliary contacts all in a NEMA enclosure.

5. Three Phase Combination Starter and Fusible Disconnect Switch Square D Class 8538 with a NEMA enclosure including a three pole fusible switch and a starter with three overloads, 120 volt control transformer with 2 primary and 1 secondary fuses, heavy-duty 30 mm, hand off automatic selector switch and heavy-duty 30 mm pilot light and N.O. auxiliary contacts.

6. Fractional HP Single Phase Manual Starters Square D Class 2510 Type F, toggle switch operated with lock-out guard, single thermal overload. Furnish starters single speed with or without pilot lights as indicated on the drawings. All surface mounted starters shall be mounted in a 'FS' conduit box.

7. Integral HP Single Phase Manual Starters – Square D Class 2510 Type M, push button operated, lock-out guard, single thermal overload in NEMA enclosure. Furnish with or without pilot light and auxiliary contacts as indicated on drawings.

8. Selector Switches and Pushbutton Stations Square D Class 9001 heavy duty 30 mm in NEMA enclosure.

9. Provide a 3” wide x 1½” high phenolic nameplate reading the following for each motor starter:

| | |
|---|---|
| **EQUIPMENT IDENTIFICATION** | **(3/8” Lettering)** |
| **Size ‘_’, __A Overload** | **(1/4” Lettering)** |
| **FED FROM _____** | **(1/4” Lettering)** |

10. Relays Square D Class 8501 with 120-volt coil in NEMA 1 enclosure. Furnish with number of poles indicated on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. CONTROL AND INTERLOCK WIRING

1. The Electrical Contractor shall furnish and install control and interlock wiring as shown on the electrical drawings. Control and interlock wiring required by Division 22 or 25 but not shown on the electrical drawing shall be the responsibility of the Division 22 or 25 Contractor requiring the wiring.
2. Generally, this will mean that Division 26 wires the series safety circuit to the magnetic starters, furnished with Hand Off Auto selector switches, using switches and devices furnished by the Mechanical Contractor.
3. Starter automation, as required by the temperature control sequence of operation, will be provided and wired by Division 22 or 25 with connections made to terminals on the automatic side of the selector switch and on starter coil auxiliary contacts.
4. The intention is that Division 26 furnish and install all wiring necessary to operate the magnetic starters with the selector switch in the Hand position and that Division 22 or 25 provide all additional automation required.
5. Relays, electropneumatic relays, and any other device required by Division 22 or 25 to operate in parallel with the starter coil shall be controlled through spare auxiliary contacts on the starter furnished by Division 26 and shall not be connected to the starter coil.
6. Single-phase motors generally are controlled by line voltage controllers furnished by the Temperature Control Contractor but installed by the Electrical Contractor. If the control sequence is more complicated than a single line voltage device such as a unit mounted thermostat, a relay or control device with a horsepower rated contact will be provided by the Temperature Control Contractor for installation by the Electrical Contractor adjacent to the motor disconnect device. The Electrical Contractor shall provide power-wiring connections to this control device. Temperature Control Contractor will provide control and interlock wiring to this control device.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect contactors:

1) Verify mechanical operation.
2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:
1) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

a. Comply with the recommendations of NFPA 70B, "Testing and Test Methods" Chapter, "Infrared Inspection" Article.
b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each motor controller 11 months after date of Substantial Completion.
d. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:

1) Description of equipment to be tested.
2) Discrepancies.
3) Temperature difference between the area of concern and the reference area.
4) Probable cause of temperature difference.
5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
6) Load conditions at time of inspection.
7) Photographs and thermograms of the deficient area.
8) Recommended action.

e. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.

f. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

**END OF SECTION 26 29 13**

# SECTION 26 29 23 – VARIABLE FREQUENCY DRIVES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Variable frequency drives
   2. Control devices
   3. Interconnection wiring

B. The Electrical Contractor shall provide variable frequency drives as shown on the drawings. The Electrical Contractor shall furnish and install the controller, control devices, and interconnection wiring as specified below.

### 1.2 ACTION SUBMITTALS

A. Product Data

B. Shop drawings
   1. Dimensioned drawings.
   2. Operation and installation manuals.
   3. Maintenance, adjustment, part breakdown and troubleshooting manual.
   4. Connection diagrams.
   5. Schematic diagrams including printed circuit boards, wiring harnesses, and enclosure mounted controls.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation manual

### 1.4 CLOSEOUT SUBMITTALS

A. Operation Manual:

B. Parts List: For each type of product that has replaceable parts.

PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. YASKAWA Z1000

## 2.3 DRIVE GENERAL DESCRIPTION

A. Furnish and install variable frequency drives as specified herein. The assembly shall include a circuit breaker or input fuses, motor overload relay(s) and operational options required by this specification.

B. A factory authorized trained technician shall make final adjustments and settings on the drives and shall submit a field report to the Engineer stating the setpoints and ramp time settings on each drive.

## 2.4 DRIVE COMPONENTS

A. The variable frequency drive system shall include a diode bridge rectifier, DC link reactor for reduction of harmonics, capacitor filter, and IGBT inverter section. The output shall be capable of a 12khz sine coded pulse width modulated output for quiet operation. The drive ratings shall be based upon 8khz output.

B. Refer to Mechanical Electrical Interface for maximum carrier frequency rating.

C. For sound sensitive areas, the variable frequency drive system shall include a diode bridge rectifier, DC link reactor for reduction of harmonics, capacitor filter, and IGBT inverter section. The output shall be capable of a 12khz sine coded pulse width modulated output for quiet operation. The drive ratings shall be based upon 12khz output. Field tune carrier frequency at startup.

Per specifier note: Review plans for motors and VFDs located outside of mechanical rooms that would pose acoustical concerns.

Include VFD Special Conditions Feeder Schedule on plans

D. The controller shall include the following devices:
1. Drive manual on off auto selector switch to manually energize or de energize the drive control system.
2. Manual speed selector to allow a specified speed to be selected and maintained if the manual off automatic selector switch is in the manual position.

3. [Integral line side disconnect switch or circuit breaker, contactors, and thermal overload relays for each motor on drives controlling multiple motors.]
4. 4-20 milliamp output that is directly proportional to drive speed.

E. Provide a 3" wide x 1" high phenolic nameplate for each starter or disconnect as follows:

**EQUIPMENT IDENTIFICATION** **(3/8" Lettering)**
**__AS/__AF (XX AMP SWITCH/XX AMP FUSE)** **(1/4" Lettering)**

**OR**

**EQUIPMENT IDENTIFICATION** **(3/8" Lettering)**
**Size '_', __A Overload** **(1/4" Lettering)**

F. The system protection as a minimum will provide the following:
1. Overcurrent protection of 100% continuous, 110% for 1 minute.
2. Instantaneous overcurrent trip at 150%.
3. Current limit stall prevention shall be adjustable 10 to 110%.
4. Ground fault protection.
5. Current limiting DC bus fuse.
6. Overvoltage protection.
7. Undervoltage protection.

G. When the drive faults, the drive shall activate a 1NO, 1NC-fault relay display for indication of type of trip.
1. OC: Overcurrent trip at 150%
2. OCA: Overcurrent on start up
3. OCL: Overcurrent on output
4. OL: Overload
5. OP: Overvoltage due to power surge
6. OP2: Overvoltage while deceleration
7. POFF: Undervoltage
8. OH: Overheat
9. EF: Ground faults

H. Auto restart shall be a standard feature of the drive as follows:
1. Auto restart enabled or disabled by jumper or keypad selection.
2. If auto restart is selected the microprocessor shall determine, in the event of a fault, if a restart should be attempted. A restart will be attempted under the following condition:
3. Undervoltage (UP) Every time as soon as voltage returns to a safe level. Fault relay is not activated.
4. Input Overvoltage (OPS) and DC Bus Overvoltage (OP) Every time if voltage returns to normal within 30 seconds, fault relay is not activated.
5. Overcurrent (OC) Drive delays 1 second and attempts a restart. If drive trips a second time it delays 2 seconds and attempts a second restart. Overall, five attempts are made after successive delays of 1, 2, 4, 8 and 16 seconds. If the restart fails, the drive locks out and sets the fault relay on. (Number of restarts and time delays to be adjustable via keypad or jumpers).
6. A restart will not be attempted for any other type of fault and the drive will trip out immediately, activate the fault relay and make the appropriate indication on the display.

I. In the event of a fault trip the microprocessor shall save the status of the drive at the time of the fault and make that information available on the display until the drive is reset or the control power is removed.

J. An undervoltage condition of less than 100 ms duration shall not affect drive operation. If main power falls below 85% of rated voltage for longer than 100 ms while control power is retained the drive shall forcibly decelerate the load in an attempt to force a higher bus voltage through regeneration. This feature, depending on the inertia of the load, shall allow the drive to "ride through" a longer condition.

K. A minimum of 3% DC link or line reactor.

L. Operation functions shall include the following:
   1. Acceleration and deceleration time independently adjustable from .1 to 1200 seconds.
   2. Signal follower 0 5VDC, 0 10VDC, 4 20ma, 0 20ma, 1 5VDC, or 0 135 ohms selectable. An increasing input signal can command increasing or decreasing frequency as required by the application.
   3. Ramp to stop or coast to stop for normal operation (coast to stop on fault).
   4. Volts/Hertz patterns selectable by keypad.
   5. Upper and lower frequency limit adjustments shall be available. When the drive reaches one of the limits it shall activate an open collector signal available to the user. A dry contact signal shall be available as an option.

M. Drives shall have a Short Circuit Current Rating (SCCR) of 100,000 amps.

N. Three Contactor By-Pass:
   1. Provide a three-contactor by-pass.
   2. Normal/by-pass selector switch.
   3. The bypass contactors shall be mechanically and electrically interlocked

## 2.5 INSTALLATION

A. Provide housekeeping pads for all floor mounted equipment.

B. Control and interlock wiring
   1. The Electrical Contractor shall furnish and install control and interlock wiring as shown on the electrical drawings. Control and interlock wiring required by Division 22 or 25 but not shown on the electrical drawing shall be the responsibility of the Division 22 or 25 Contractor requiring the wiring.
   2. Generally, this will mean that Division 26 wires the series safety circuit to the magnetic starters, furnished with Hand Off Auto selector switches, using switches and devices furnished by the Mechanical Contractor.
   3. Starter automation, as required by the temperature control sequence of operation, will be provided and wired by Division 22 or 25 with connections made to terminals on the automatic side of the selector switch and on starter coil auxiliary contacts.
   4. The intention is that Division 26 furnish and install all wiring necessary to operate the magnetic starters with the selector switch in the Hand position and that Division 22 or 25 provide all additional automation required.

5. Relays, electropneumatic relays, and any other device required by Division 22 or 25 to operate in parallel with the starter coil shall be controlled through spare auxiliary contacts on the starter furnished by Division 26 and shall not be connected to the starter coil.
6. Single-phase motors generally are controlled by line voltage controllers furnished by the Temperature Control Contractor but installed by the Electrical Contractor. If the control sequence is more complicated than a single line voltage device such as a unit mounted thermostat, a relay or control device with a horsepower rated contact will be provided by the Temperature Control Contractor for installation by the Electrical Contractor adjacent to the motor disconnect device. The Electrical Contractor shall provide power-wiring connections to this control device. Temperature Control Contractor will provide control and interlock wiring to this control device.

**END OF SECTION 26 29 23**

# SECTION 26 43 13 – SURGE PROTECTIVE DEVICES (SPD)

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Surge protective devices (SPD's), formerly TVSS

### 1.2 ACTION SUBMITTALS

A. Product Data
   1. Submittal shall include a copy of the SPD performance parameters listed at www.UL.com under Certifications, searching using Category Code: VZCA, to verify SCCR, VPR, MCOV, I-n, and Type 1 compliance with this specification. "Manufactured in accordance with" is not equivalent to UL listing and does not meet the intent of this specification.

### 1.3 INFORMATIONAL SUBMITTALS

A. Installation Manual

### 1.4 CLOSEOUT SUBMITTALS

A. Operations Manual

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Eaton

B. Current Technology

C. LEA

D. APT

E. Schneider Electric

F. Environmental Potentials

2.3 STANDARDS

A. Must be listed or comply with the most recent editions of:
1. Underwriters Laboratories: UL1449 and UL 1283
2. ANSI/IEEE C62.41.1-2002, C62.41.2-2002, C62.45-2002
3. National Electrical Code: Article 285
4. NEMA LS-1(rescinded Aug 19, 2009, replacement undetermined)

2.4 SURGE PROTECTIVE DEVICES

A. SPD shall be UL labeled with a 200kA Short Circuit Current Rating (SCCR), as a Type 1 device, and a 20kA I-nominal (I-n) rating.

B. Minimum surge current capability (single pulse rated) per phase shall be:
1. Service Entrance: 300kA
2. Distribution panelboards & MCC: 200kA
3. Branch panelboards: 100kA

C. UL 1449 Listed Voltage Protection Ratings (VPRs) shall not exceed the following:

| System Voltage | L-N | L-G | L-L | N-G | MCOV |
|---|---|---|---|---|---|
| 208Y/120 | 700V | 700V | 1200V | 700V | 150V |
| 480Y/277 | 1200V | 1200V | 1800V | 1200V | 320V |

D. SPD shall include visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.

E. All units shall also include a surge counter mounted in the enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. SPD shall be installed in accordance with the manufacturer's installation manual using the recommended breaker and wire sizes.

B. The SPD unit shall be located as close as is practical to the switch or circuit breaker serving the unit. All efforts shall be made to locate the switch or circuit breaker in a place where the SPD leads are as short as possible. In no case shall the factory SPD leads be extended or spliced.

C. All of the SPD units shall be provided in a NEMA 1 or 12 enclosure, unless otherwise specified.

**END OF SECTION 26 43 13**

# SECTION 26 51 00 – LED LIGHTING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. LED luminaires

B. Related Requirements:
   1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 26 09 43 “Network/Addressable Lighting Controls” for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   3. Drawings for Luminaire Schedule.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   6. Include sample warranty.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Submit factory drawings with the following additional information included:
      a. Plans, elevations, sections, and mounting and attachment details.
      b. Details of luminaire assemblies. Indicate dimensions of fixture including individual lens lengths, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      c. Diagrams for power, signal, control wiring, and emergency lighting locations.
      d. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
      e. Product Certificates: for each type of Luminaire.
      f. Product Test Reports: For each luminaire, for test performed by a qualified testing agency.
      g. Sample warranty.

### 1.3 PRODUCT SUBSTITUTIONS

A. Product Substitutions shall be submitted 10 days in advance of bid-day. All products included in bid shall be of equal or better quality to the basis of design.

## 1.4 INFORMATIONAL SUBMITTALS

A. Not required.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
   1. Provide a list of all Lamps/LED Light Bars & Drivers/Transformers used on Project; use ANSI and manufacturers' codes.

## 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. Lamps/LED Light Bars: One for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Drivers/Transformers: One for every 100 of each type and rating installed. Furnish at least one of each type.

## 1.7 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

2.2 MANUFACTURERS

A. Refer to Luminaire Schedule on the drawings.

2.3 LED LIGHTING

A. Quality Assurance
1. Luminaire Photometric Data Testing Laboratory Qualifications:
a. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
b. Provided by 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, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
2. Provide luminaires from a single manufacturer for each luminaire type.
3. Each luminaire type shall be binned within a three-step MacAdam Ellipse or better to ensure color consistency among luminaires.

B. Warranty
1. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
2. Warranty Period: From date of Substantial Completion.
a. Manufacturer: Five years minimum, unless otherwise noted.
b. Installer: One year minimum, unless otherwise noted.

C. Performance Requirements
1. Seismic Performance:
a. Luminaires shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
b. Luminaires and lamps shall be labeled vibration and shock resistant.
c. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified.
2. Ambient Temperature: 41 to 104 deg F.
3. Relative Humidity: Zero to 95 percent.

D. Luminaire Requirements
1. 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. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place. Labels shall include but not limited to CCT, CRI and Lumens.
3. CRI of minimum 80. CCT of 3500K (interior). 4000K (exterior)
4. Related minimum luminaire life of 100,000 hrs to L70.
5. Luminaire dimmable from 100 percent to 10 percent of maximum light output unless otherwise specified on Luminaire Schedule.
6. All recessed fixtures less than 3” in diameter have accessibility to driver without reaching into ceiling cavity.
7. Lens:

a. Acrylic diffusers: 100% virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
b. At least 0.125 inch minimum unless otherwise indicated on Luminaire schedule.
8. Housings: See luminaire schedule for exact requirements.
9. Recessed luminaires shall comply with NEMA LE 4.

E. Materials
1. Metal Parts:
a. Free of burrs and sharp corners and edges.
b. Sheet metal components shall be steel unless otherwise indicated.
c. Form and support to prevent warping and sagging.
2. Steel:
a. ASTM A36/A36M for carbon structural steel.
b. ASTM A568/A568M for sheet steel.
3. Stainless Steel:
a. Manufacturer's standard grade.
b. Manufacturer's standard type, ASTM A240/240M.
4. Galvanized Steel: ASTM A653/A653M.
5. Aluminum: ASTM B209.
6. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions.
7. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidently during relamping and when secured in operating position

F. METAL FINISHES
1. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

## PART 3 - EXECUTION

### 3.1 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

### 3.2 EXAMINATION

A. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. EC shall receive approval from engineer/lighting designer prior to luminaire installation when there is a layout change due to unforeseen conditions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.3 TEMPORARY LIGHTING

A. If approved by the Architect, Engineer and Lighting Designer, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting.

## 3.4 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings, walls and finished grade unless otherwise indicated.

C. Aim as indicated on Drawings.

D. Install per manufacturer's installation instructions.

E. Supports:
  1. Sized and rated for luminaire weight.
  2. Able to maintain luminaire position after cleaning and relamping.
  3. Provide support for luminaire without causing deflection of ceiling or wall.
  4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Flush-Mounted Luminaires:
  1. Secured to outlet box.
  2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
  3. Trim ring flush with finished surface.

G. Wall-Mounted Luminaires:
  1. Attached to structural members in walls
  2. Do not attach luminaires directly to gypsum board.

H. Suspended Luminaires:
  1. Ceiling Mount:
     a. Aircraft cable size and support locations per manufacturer's requirements. See drawings for exact length.
     b. Aircraft cable supports and quantity per manufacturer's requirements. See drawings for exact length.
     c. Hook mount.
  2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
  3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
  4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing, rod, or wire support for suspension for each unit length of luminaire chassis, including one at each end.
  5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure. See seismic detail on drawings.

I. Ceiling-Grid-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
   3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

## 3.5 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or as indicated on fixture details on drawings. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

## 3.6 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with pipe-wrapping plastic tape applied with a 50 percent overlap.

## 3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing luminaires, lighting controls, and accessories, and after electrical circuitry has been energized, test luminaires with controls to confirm proper operation. Any defective component in the lighting systems shall be replaced and the system reprogrammed if necessary.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
   3. Illumination Tests:
      a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
         1) IES LM-5.
         2) IES LM-72.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

## 3.8 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

**END OF SECTION 26 51 00**

# SECTION 26 52 13 – EMERGENCY LIGHTING TRANSFER DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Emergency lighting transfer device (LTB)
   2. Lighting transfer switch (LTS)

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 EMERGENCY LIGHTING TRANSFER DEVICE

A. Lighting Transfer/Bypass Device (LTB) with Remote Test Button
   1. UL 924 listed.
   2. Contact ratings:
      a. 20 amp magnetic ballast @ 277 Vac
      b. 16 amp electronic ballast @ 277 Vac
   3. Bypasses local manual or automatic lighting controls so an emergency luminaire provides full brightness during a power outage. Normally downstream of a UL 1008 listed Automatic Transfer Switch (ATS) or Lighting Transfer Switch (LTS).
   4. Includes a dry contact to interrupt 0-10V dimming control circuit.

5. Includes remote test input to be used with Functional Devices Remote Test Button #ESRTB (or equivalent). Provide and install the Remote Test Button in an accessible location flush in the ceiling or above 80"AFF on wall or where indicated on the drawings.
6. Functional Devices Automatic Load Control Relay #ESRN or equivalent.

2.3 LIGHTING TRANSFER SWITCH (LTS)

A. UL 1008 listed.

B. Contact ratings:
   1. 20 amp lighting load @120-277 Vac

C. Switches between a normal and emergency source/circuit.

D. Includes a dry contact to interrupt 0-10V dimming control circuit.

E. Myers Branch Circuit Emergency Lighting Transfer Switch #EPC-D-F-LS or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION
   1. Install per manufacturer's recommendation.

3.2 FIELD QUALITY CONTROL
   1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

END OF SECTION 26 52 13

# SECTION 27 05 28 – PATHWAYS FOR COMMUNICATIONS SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Pathways
   2. Hangers and supports
   3. Conduit and bacboxes

A. Work Included:
   1. Furnish material, labor and services necessary for, and incidental to, installing the following systems where shown on the Plans and as hereinafter specified. Include all necessary work in the related sections of the Specifications to provide for complete systems.

### 1.2 ACTION SUBMITTALS

A. Not required

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

### 1.5 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
   1. Division 26 – Electrical
   2. Division 28 – Electronic Safety and Security

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

PART 3 - EXECUTION

3.1 PATHWAYS

A. All cabling shall be as shown on plans, and per specifications.

B. Cabling may be run as open-type plenum rated cable concealed above lay-in ceiling spaces. Non plenum rated cabling shall be installed in conduit. Cabling shall be installed in conduit in all exterior locations and in all exposed or inaccessible locations including all open to structure, cloud ceilings, inside wall partitions or above drywall, wood, and other inaccessible ceilings.

C. Cabling may be run as open-type plenum rated cable concealed above lay-in ceiling space and exposed open to structure above or cloud type ceilings unless noted below. Cabling shall be installed above bar joist flanges to conceal cabling from view when routed through exposed ceiling. Non plenum rated cabling shall be installed in conduit. Cabling shall be installed in conduit in all exterior locations, all areas exposed below 8’ A.F.F., and all inaccessible locations including inside wall partitions or above drywall, wood, and other inaccessible ceilings. Cabling shall be installed in conduit in the following spaces:

1. Electrical, Mechanical Equipment Rooms
2. Storage and Janitor Closets
3. Blackbox Theater
4. Scene Shop
5. Multipurpose Room
6. Classrooms
7. Auditorium/Theater
8. Stairwells
9. Shell space
10. Restrooms
11. Tunnels

D. Cables shall be continuous from outlet to termination equipment.

E. Cables shall be terminated using tools recommended by the termination manufacturer.

F. Furnish and install a minimum of one (1) acoustical cable pathway device through all walls in which cable runs pass through. Device shall be Specified Technologies, Inc. NEZ44 or equivalent.

G. Furnish and install a minimum of one (1) cable pathway device through fire rated partitions and floors, and where indicated on the drawings. Device shall be Specified Technologies, Inc. EZDP44FWS, 3M QuickPass, or equivalent.

H. Refer to other divisions for fire sealing of penetrations through fire rated walls.

I. Provide access panels as necessary for cable routing.

3.2 HANGERS AND SUPPORTS

A. Cables shall be supported with “J-Hooks” a minimum of every four feet. Support devices are to be attached to existing permanent structure. J-Hooks must be located no more than 12” on each side of a change of direction.

B. Cables shall be installed in cable tray where available.

C. Cables and supports shall be installed at a readily accessible location above ceilings.

3.3 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

A. Furnish and install conduit rough-ins at all outlets locations where shown on drawings. Rough-in shall consist of a 4” square outlet box, single gang plaster ring, and a minimum 1” conduit stubbed above an accessible ceiling to the nearest cable pathway. Plastic bushings shall be installed on both ends of conduit. Install blank covers on all unused rough-ins.

B. All conduits serving telephone/data communication outlets shall be 1” minimum. Conduits for all other system cable runs shall be sized for 40% maximum fill, or as shown on the drawings. Redundant paths shall be installed where fill exceeds 40%.

C. Provide pull strings in all conduits.

D. Conduit bends shall accommodate radius requirements of fiber cable as necessary.

3.4 GENERAL REQUIREMENTS

A. Under no circumstances shall cables be painted.

B. The contractor shall coordinate with MSU Networking and Telecommunications to accommodate the appropriate amount of time for all parties to complete activities.

C. Rough-ins <u>*shall not*</u> be daisy chained.

**END OF SECTION 27 05 28**

# SECTION 27 13 23 – COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Optical fiber backbone cable
   2. Buffer tube fanout kits
   3. Optical fiber connectors
   4. Fiber enclosures

B. Work Included:
   1. Furnish material, labor and services necessary for, and incidental to, installing the following systems where shown on the Plans and as hereinafter specified. Include all necessary work in the related sections of the Specifications to provide for complete systems.

### 1.2 ACTION SUBMITTALS

A. Product Data

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers installation instructions

### 1.4 CLOSEOUT SUBMITTALS

A. As-built drawings providing identification and routing of all fiber cabling.

### 1.5 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
   1. Division 26 – Electrical
   2. Division 28 – Electronic Safety and Security

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

### 2.2 MANUFACTURERS

A. Commscope or equivalent

### 2.3 FIBER OPTIC CABLE SYSTEMS

A. Where indicated on the drawing fiber shall be Commscope Arid-core 6-Strand Multi-mode #O-006-LA-6F-F-OR.

B. Fiber cable shall be broken out into individual fibers by use of buffer tube fan-out kits and loose tube cable for furcation kits by Commscope.

C. Each strand shall be terminated with a Uni-Cam SC type ceramic connector, #MFC-SCU-29 for multi-mode, at each end as manufactured by Commscope.

D. Furnish and install Fiber Enclosures in the equipment racks in the telecom rooms as indicated on the drawings. Fiber Enclosures are to be Commscope #RFE-SLC-024-MFA-SC06

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Each strand shall be identified by a label at each end.

B. Coordinate location of fiber enclosures within racks with Owner's Representative.

C. All fibers shall be continuous, without splice, from end to end.

### 3.2 TESTING

A. Testing shall be of the optical link. An optical fiber link is defined as the passive cabling network between two optical cross-connects (patch panels or outlets). This includes cable, connectors and splices but does not include active components. The link test contains the representative connector loss at the patch panel associated with the mating of patch cords but does not include the performance of the connector at the equipment interface. All cabling not tested strictly in accordance with these procedures shall be re-tested at no additional cost to the Owner. 100% of the installed cabling must be tested. All tests must pass acceptance criteria defined herein.

B. Unless otherwise specified, multimode and single-mode fiber cable must meet the transmission performance parameters as specified in ANSI/TIA/EIA-568-B.3.

C. Link attenuation shall be tested in accordance with ANSI/TIA/EIA-526-14A. Reference measurements shall be made in accordance with method B or equivalent. Optical loss shall be measured on each fiber at 850 nm and 1300 nm. Loss shall be measured on each fiber from each direction (bi-directionally), unless it is known in advance which fibers shall transmit ($T_X$) and receive ($R_X$).

D. Link length shall be optically measured or calculated using cable sheath length markings.

E. Cabling shall meet the following loss and length.

| | |
|---|---|
| Attenuation 850 nm: | ≤ fiber length (km) x 3.75 dB/km<br>+ number connector pairs x 0.75 dB<br>+ number of splices x 0.3 dB |
| Attenuation 1300 nm: | ≤ fiber length (km) x 1.5 dB/km<br>+ number connector pairs x 0.75 dB<br>+ number of splices x 0.3 dB |
| Length: | ≤ 2000 m (6560 ft) |

F. Test reports may be submitted in hardcopy and/or electronic format. Hand-written test reports are not acceptable.

G. Hardcopy reports are to be submitted in labeled 3 ring binders with a witness signature verifying passing execution of all tests.

H. Electronic reports are to be submitted on 3.5 inch diskettes or CD format. Disk or CD shall contain the software required to view test results. Electronic reports must be accompanied by a Certificate signed by an authorized representative of the Contractor warranting the truth and accuracy of the electronic report. Certificate must reference traceable circuit numbers that match the electronic record.

I. Test reports shall include the following information for each cabling element tested:
1. Actual measured and maximum allowable attenuation (loss) at the specified wavelengths and the margin. An individual test that fails the link criteria shall be marked as FAIL.
2. Reference method.
3. Number of mated connectors and number of splices (if any).
4. Actual length and maximum allowable length per Part 2 Section 3. Any individual test that fails the link length criteria shall be marked as FAIL.
5. Group refractive index (GRI) for the type of fiber tested, if length was optically measured.
6. Tester manufacturer, model, serial number and software version.
7. Circuit ID number and project/job name.
8. Link criteria (Autotest) used.
9. Overall pass/fail indication.
10. Date and time of test.

J. Test reports shall be submitted within 7 business days of completion of testing.

K. Test equipment used under this contract shall be from manufacturers that have a minimum of 5 years experience in producing field test equipment. Manufacturers must be ISO 9001 certified. All test tools of a given type shall be from the same manufacturer, and have compatible electronic results output.

L. Test equipment shall be capable of measuring relative or absolute optical power in accordance with TIA/EIA-526-14A, "Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant," and TIA/EIA-526-7 method A, "Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Insertion Loss Using An Optical Power Meter."

M. Test equipment shall not include the loss or length of the test jumpers in the cable plant measurements.

N. Multimode test equipment shall incorporate both 850 nm and 1300 nm sources in same unit. The coupled output power into multimode fiber shall be ≥ -20 dBm at each wavelength. Detectors shall have a dynamic range of at least +3 dB to –55 dB.

O. Sources and meters shall automatically synchronize wavelengths to prevent calibration-related errors.

P. The time-of-flight methodology shall be employed when optically measuring fiber length.

Q. Test equipment capable of measuring a Tx/Rx fiber pair simultaneously is recommended to enhance productivity.

R. Contractor must warrant in writing that 100% of the installation meets the requirements specified above.

S. Owner reserves the right to conduct, using Contractor equipment and labor, a random re-test of up to five (5) percent of the cable plant to confirm documented results. Any failing cabling shall be re-tested and restored to a passing condition. In the event more than two (2) percent of the cable plant fails during re-test, the entire cable plant shall be re-tested and restored to a passing condition at no additional cost to the Owner.

T. Acceptance shall be subject to completion of all work, successful post-installation testing which yields 100% PASS rating, and receipt of full documentation as described in Part 2, section 4.

U. Contractor shall warrant Installation against all product defects, and that all approved cabling components meet or exceed the requirements of this document.

**END OF SECTION 27 13 23**

# SECTION 27 15 13 – COMMUNICATIONS COPPER HORIZONTAL CABLING SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Copper horizontal cable
   2. Modular jacks and faceplates
   3. Terminal blocks and patch panels
   4. Equipment racks

B. Work Included:
   1. The Electrical Contractor shall furnish and install all materials, accessories, and labor required to install a new telephone and/or data cabling system or an operational extension of the existing telephone and/or data cabling system.
   2. The Contractor shall be trained and certified by the equipment manufacturer.
   3. The Contractor shall attend coordination meetings with the Owner and Engineer prior to installation.

### 1.2 ACTION SUBMITTALS

A. Product Data

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers installation instructions

### 1.4 CLOSEOUT SUBMITTALS

A. Provide as-built drawings indicating cable routing and cable/jack/patch panel identification.

### 1.5 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
   1. Division 26 – Electrical
   2. Division 28 – Electronic Safety and Security

PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Homaco

B. Panduit

C. Hoffman

## 2.3 CABLING

A. One Four-pair category 6 23 gauge MPP/CMP plenum rated 100 ohm UTP cables to be designated as station voice to be wired at wall outlet on (UNJ600-BK) modules using T568B wiring scheme termination at wall outlet per manufactures specification and at the closet end on patch panels (part #UNP610-24P) using the T568B wiring scheme. These cables shall be designated as V1 along with the outlet number assigned. Place the ivory voice icon (UNJ-ICON-IV) in the designated area on jack.

B. One Four-pair category 6, 23 gauge MPP/CMP plenum rated UTP cables to be designated as station network to be wired at wall outlet on (UNJ600-BK) modules using T568B wiring scheme termination at wall outlet per manufactures specification and at the closet end on patch panels (part #UNP610-24P) using the T568B wiring scheme. These cables shall be designated as N1 along with the outlet number assigned. Place the ivory data icon (UNJ-ICON-IV) in designated area on jack.

C. Cable jacket color shall be in accordance with the building standards.

D. Cables shall not exceed 90 meters from termination location to wall outlet.

## 2.4 TELEPHONE/DATA CABLING SYSTEMS EQUIPMENT

A. Furnish and install faceplate and modular jacks at each Voice/Data outlet as described below:
1. One Panduit single gang Sloped Modular Flush-Mount Faceplate (part #CFPSL4EIY).
2. One Panduit Mini-Com modular jack to be designated as stations Voice (part #CJ688TGEI).
3. Two Pandit Mini-Com modular jacks to be designated as stations Network (part #CJ688TGBU).
4. Furnish, install and terminate one Voice, and two Network cable for each outlet.

B. Furnish and install faceplate and modular jacks at each Voice outlet as described below:
1. One Panduit single gang Sloped Modular Flush-Mount Faceplate (part #CFPSL2EIY).

2. One Panduit Mini-Com modular jack to be designated as stations Voice (part #CJ688TGEI).
3. Furnish, install and terminate one Voice cable for each outlet.

C. Furnish and install faceplate and modular jacks at each Data outlet as described below:
   1. One Panduit single gang Sloped Modular Flush-Mount Faceplate (part #CFPSL2EIY)).
   2. Two Panduit Mini-Com modular jacks to be designated as stations Network (part #CJ688TGEI).
   3. Furnish, install and terminate two Network cables for each outlet.

D. Furnish and install faceplate and modular jacks at each Non-Standard Voice/Data outlet as describe below:
   1. One Panduit Sloped Modular Flush-Mount Faceplate in size as required to accommodate number of terminations.
   2. Panduit Mini-Com modular jacks to be designated as stations Network (part #CJ688TGEI) in quantity as indicated on the drawings.
   3. Furnish, install and terminate Network cables for each outlet.
   4. One Panduit Mini-Com modular jack to be designated as stations Voice (part #CJ688TGEI) in quantity as indicated on the drawings.
   5. Furnish, install and terminate Voice cables for each outlet.

E. Furnish and install Commscope terminal blocks on designated wall in Telecommunications Room for termination of voice cables. Terminate voice cabling with sufficient slack to allow for future relocation to a patch panel in the network rack. Furnish and install 19" racks, patch panels and horizontal management for termination of network cables and fiber.
   1. Provide Panduit (part #UICMPPK6G24BL) category six patch panels for network terminations.
   2. Provide and install Panduit (part #CMR19x84 or equivalent by Homaco) equipment racks in quantity and locations as follows:
      a. (2) Equipment Racks in Art Annex Second Floor IT Room
   3. Each rack shall have Panduit vertical cable management (Part #WMPV45E) mounted on each side, and Panduit horizontal cable management (Part #WMP1E) mounted between each switch or patch panel. Provide and install a minimum of two Leviton (part # 5500-192) 19" rack mount power strips with surge suppression for power to the electronic equipment.
   4. Note: All cables routed from Telecommunications Room out to wall outlets shall be routed within Telecommunication Room to equipment racks on ladder racking or cable runway, this shall be furnished and installed in a Black Finish. The equipment racks have a 12" ladder channel on top to accept runway. Junction Splices, Butt-splices, Radius drop kits, wall angles, rack to runway mounting plates, and corner support brackets shall be furnished in quantities required for proper installation.

F. Labeling and Standards
   1. Cables at wall outlets and terminations at communication closet shall be identified and labeled as follows, depending on typical vs non typical.
      Typical
      V1 - first telephone (or voice) cable at a given outlet.
      N1 - first network cable at a given outlet
   2. The first location shall start with the number (1) and continue, labels at wall outlet shall be TIA/EIA-606 Compliant

3. All of work described above shall be ANSI/TIA/EIA-568B.1, B.2, B.3-1 & 569B compliant and follow NEC codes local or otherwise.
4. All voice and network terminations at communication closet shall be terminated on patch panels and 19" racks permanently mounted on floor of Telecommunication Room. Cables shall be terminated in distinct and separate panels for each type; voice, building network, and research network.

G. Voice cable shall be Panduit (#PUP6004WH-U White) Plenum. Network cable shall be Panduit (#PUP6004BU-U Blue) Plenum. No equivalents accepted. All of the above mentioned equipment and scope of work shall be properly grounded and bonded per TIA/EIA-607.

H. Provide 10- Commscope (#UNC6-XX-10F-B) and 20- Commscope (#UNC6-XX-5F-B) Modular Interface patch Cords for use in Telecommunications Room and at work outlet for Network.

## PART 3 - EXECUTION

### 3.1 ROUGH-INS

A. Furnish and install rough-ins where shown on drawings. Rough-in shall consist of a two-gang outlet box, single gang trim ring, and a minimum 1” conduit stubbed above an accessible ceiling. Install blank covers on all unused rough-ins.

B. Maximum fill of conduit is not to exceed forty percent.

C. Furnish and install minimum 2” sleeve through fire rated partitions.

D. Refer to 26 05 29 for fire sealing of penetrations through fire rated walls.

### 3.2 Testing and Labeling

A. Field test data cables after installation for acceptance as defined in ANSI/TIA-1152 (and/or IEC 61935-1). Acceptance tests to include continuity, length, attenuation, crosstalk, and noise. The results of all tests for each cable will be documented in a printout from the test instrument and provided to the owner. Any cables which fail will be corrected and re-tested with the new test results provided to owner.

B. Label jacks at outlet faceplates and patch panels and label cables at the outlets and other termination location in accordance with the building standards.

C. Provide colored cables and jacks in accordance with the building standards.

**END OF SECTION 27 15 13**

# SECTION 27 15 33 – COMMUNICATIONS COAXIAL HORIZONTAL CABLING SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes: Outlets and faceplates
  2. Splitters

B. Work Included:
  1. Furnish material, labor and services necessary for, and incidental to, installing the following systems where shown on the Plans and as hereinafter specified. Include all necessary work in the related sections of the Specifications to provide for complete systems.

### 1.2 ACTION SUBMITTALS

A. Product Data

### 1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers installation instructions

### 1.4 CLOSEOUT SUBMITTALS

A. As-built drawings

### 1.5 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
  1. Division 26 – Electrical
  2. Division 28 – Electronic Safety and Security

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 PRODUCTS

A. RG-6/U Coaxial Cable

B. Coaxial F Connectors

C. 8 Port Splitters

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Furnish and install cable television system rough ins where shown on drawings. Rough in shall consist of a two gang outlet box, single gang trim ring, and a 1" conduit stubbed above an accessible ceiling. Install blank covers on all unused rough ins.

B. Install one RG-6/U plenum rated coaxial cable from each TV outlet to the telephone board in Data 059. Provide a minimum of 12" of slack at each outlet and five feet at the telephone boards.

C. Where not within a raceway, cable shall be installed in D-rings with five-foot spacing. D-rings shall be attached to the structure. Label all cables at each end.

D. TV outlets shall consist of a female type 'F' connector with an ivory faceplate.

E. Provide 8 port splitters at the telephone board(s) in sufficient quantity to terminate all cables or as shown on the drawings.

F. Provide as-built drawings providing identification and routing of all cables.

**END OF SECTION 27 15 33**

# SECTION 27 41 00 – AUDIO-VIDEO SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This project is for the construction of a new construction Art Annex Building and limited renovation scope in Craig Hall. The design, defined by the Project Documents, provides for the installation, programming and testing, and owner training of the Audio-Visual systems.

### 1.2 DEFINITIONS

A. RGB: Red, Green, Blue

B. RGBS: Red, Green, Blue, Sync

C. RGBHV: Red, Green, Blue, Horizontal Sync, Vertical Sync

D. Y-C: Chrominance, Luminance

E. S-Video: Chrominance, Luminance

F. DVI = Digital Video Interface

G. HDMI = High Definition Media Interface

H. SDI = Serial Digital Interface

I. HDSDI = High Definition Serial Digital Interface

### 1.3 SYSTEM DESCRIPTIONS

A. Blackbox Theater

1. Sixteen (16) channels of wireless microphones shall be provided with combined true diversity distributed antennae. The provided transmitters shall be a combination of bodypack with lapel and handheld units.

2. A flexible audio signal processor with network audio support integrated into the system for loudspeaker signal processing requirements, limiting and protection circuits, signal distribution, interface with AV control system and automated controls, and miscellaneous feeds such as media outputs and overflow spaces. Dante digital audio bus included with

audio processor allowing the system to add additional inputs and outputs as required to accommodate future changes or additions.

3. The sound reinforcement system for the Blackbox house will produce high-quality sound for speech and music for multiple seating arrangements. The speakers will consist of powered two-way speakers with low-frequency subwoofers with mounting brackets and pipe clamp accessories to allow speakers to be easily moved and repositioned in the ceiling grid as required with centrally located connectivity plate and distributed AC power receptacles. Overflow audio shall be provided to dressing rooms, MFD Studio above, and Lobby.

4. Two-channel production intercom system included with wireless intercom base units, wireless intercom beltpacks and headsets, wired intercom beltpacks and jacks. Intercom speaker stations shall be included in the dressing rooms and MFD Studio directly above the Black Box.

5. Input/output plates will be located throughout the perimeter of the lower and upper accessible area that will provide microphone inputs, tie lines, monitor speakers (line-level for powered units), HDMI video and AV and network data. The mixing console system shall have support for mobile app to allow the sound operator to roam and listen throughout the Black Box while adjusting.

6. Low light camera shall be provided to send low-latency feed to monitor locations in the control booth, dressing rooms, and classroom studios above. Data cables shall be run from Blackbox AV rack to Classroom AV rack to allow for encoded stream to travel between racks.

7. A three-chip, LCD laser projector with WUXGA resolution and 13,000 (min) lumens will be provided with motorized drop-down tensioned projection screen.

8. Stage Manager’s location will include a paging microphone for backstage areas. Additional AV inputs and AV touch panel installed in the control room to allow integrated control of system power, AV source selection and volume control and video mute.

9. An equipment cabinet will be included to house all AV equipment and will be located near the control booth.

B. Lobby

1. Distributed audio shall produce high-quality sound for background music and overflow audio from the Black Box. Head-end equipment for input and amplification shall be located in the Blackbox control booth. Local microphone and control plates located in the Lobby, allowing the Lobby to function independently of the Blackbox.
2. Digital signage display with media player shall be provided.

C. MFD Rehearsal Studios

1. Larger studios shall have four (4) channels of wireless microphones shall be provided. Three bodypack transmitters with lapel and headset microphones (one and two respectively) and one handheld microphone transmitter.

2. MFD Studio 1 shall have the ability to stream local camera and mixed room audio to endpoints such as YouTube, Facebook, etc. Contractor shall work with university to configure streaming unit properly over university network. Touch panel shall be configured with presets to allow camera and audio from room to be in "on" and "off" modes to avoid sending streams during unwanted times.

3. The sound reinforcement system will produce high-quality sound for speech and music. Distributed subwoofers shall be provided to extend the low frequency performance of the space.

4. A flexible audio signal processor with network audio support integrated into the system for loudspeaker signal processing requirements, limiting and protection circuits, signal distribution, and interface with AV control system. Dante digital audio bus included with audio processor allowing the system to add additional inputs and outputs as required to accommodate future changes or additions.

5. A three-chip, LCD laser projector with WUXGA resolution and 10,000 (min) lumens will be provided with motorized drop-down tensioned projection screen.

6. A user interface location will provide the following:

   - Wall plate in one location will provide HDMI and Bluetooth inputs.
   - Touch panel for system on/off, source select, and level control.

7. A single rack location on the second level shall be a shared head-end for all studios. The rack shall receive an encoded stream from the Blackbox as an input source for the system.

D. Acting Studios

1. Larger studios shall have four (4) channels of wireless microphones shall be provided. Three bodypack transmitters with lapel and headset microphones (one and two respectively) and one handheld microphone transmitter.

2. The sound reinforcement system will produce high-quality sound for speech and music. The speakers shall be integrated into the ceiling system to leave the walls open for flexibility.

3. A flexible audio signal processor with network audio support integrated into the system for loudspeaker signal processing requirements, limiting and protection circuits, signal distribution, and interface with AV control system. Dante digital audio bus included with

audio processor allowing the system to add additional inputs and outputs as required to accommodate future changes or additions.

4. A three-chip, LCD laser projector with WUXGA resolution and 10,000 (min) lumens will be provided with motorized drop-down tensioned projection screen.

5. A user interface location will provide the following:
   - Wall plate in one location will provide HDMI and Bluetooth inputs.
   - Touch panel for system on/off, source select, and level control.

6. The rooms shall receive an encoded stream from the Blackbox as an input source for the system.

E. DTMS Design Class

1. The sound reinforcement system will produce high-quality sound for speech and music.

2. A flexible audio signal processor with network audio support integrated into the system for loudspeaker signal processing requirements, limiting and protection circuits, signal distribution, and interface with AV control system. Dante digital audio bus included with audio processor allowing the system to add additional inputs and outputs as required to accommodate future changes or additions.

3. Two 75” flat panel monitors will be provided with duplicate content.

4. A user interface location will provide the following:
   - Wall plate in one location will provide HDMI and Bluetooth inputs.
   - Touch panel for system on/off, source select, and level control.

F. Acting Studio/Classroom 206 (Craig Hall)

1. Four (4) channels of wireless microphones shall be provided. Provide two bodypacks with lapels and two handheld microphone transmitters.

2. The sound reinforcement system will produce high-quality sound for speech and music. The speakers shall include high-quality two-way units with low-frequency subwoofer.

3. A flexible audio signal processor with network audio support integrated into the system for loudspeaker signal processing requirements, limiting and protection circuits, signal distribution, and interface with AV control system. Dante digital audio bus included with audio processor allowing the system to add additional inputs and outputs as required to accommodate future changes or additions.

4. A three-chip, LCD laser projector with WUXGA resolution and 10,000 (min) lumens will be provided with motorized drop-down tensioned projection screen.

5. A high definition motorized PTZ camera shall be provided to capture the room for remote viewing via soft-codec (Zoom). Camera signal shall return to user interface location with ability to connect USB to a BYOD computer. Microphone mixed audio signal shall be included in signal chain for remote participants.

6. A user interface location will provide the following:

   - Wall plate in one location will provide HDMI and Bluetooth inputs.
   - Touch panel for system on/off, source select, and level control of all sources.
   - Connectivity to camera and audio for soft-codec (Zoom).

1.4 SUBMITTALS

A. Prior to shop drawing submittal, contractor will submit touch screen sheet layouts to the owner for review. Programming allowance shall be made to modify touch screen pages without additional compensation.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Shop drawings and submittal data shall contain sufficient information to describe the work to be performed. Prepare drawings at an appropriate scale and submit the required number of copies (see Division 1) of the submittal package neatly bound in sets. The required information shall include but not be limited to:
   1. Detail equipment assemblies and indicate dimensions, weights, required clearances.
   2. Written verification of the Audio-Visual Contractor's qualifications as required in this section.
   3. Wiring diagrams for each system including wire types.
   4. Rack drawings showing proposed rack layout.
   5. Speaker mounting details. (Note: It is the responsibility of the Audio-Visual Contractor to assure the structural integrity of the speaker hanging method and hardware only.)
   6. All rough-in information including junction and back boxes.
   7. Layout of all custom plates outlet plates/panels.
   8. A material list of all equipment to be furnished.
   9. Manufacturers specification sheets of all equipment to be provided. (bound in a neat and orderly fashion with an index listing the manufacturer's specification sheets in specification order).

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.

E. Operation and Maintenance Data

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: The Audio-Visual Systems Contractor shall be a contractor who has been continuously engaged in furnishing and installing commercial audio and video systems of the type specified for at least five (5) years.

B. The Audio-Visual Systems Contractor shall maintain a suitably staffed and equipped service organization and shall regularly offer maintenance services for systems of this type and size.

C. The Audio-Visual Systems Contractor shall be an authorized dealer of all equipment provided with this system. Given the inherent warrantee difficulties which occur when products are provided from contractors who participate in trans-shipping or two-stepped equipment sales, this dealership requirement will be strictly adhered to. At the owner's request, any contractor responding to this bid proposal must provide proof of dealership status for all listed system components or approved alternates. Failure to comply with this request will be grounds for bid rejection.

D. At the request of the Owner, Architect or Engineer, an inspection of the Audio-Visual Systems Contractor's place of business shall be scheduled to demonstrate that the contractor possesses adequate plant and equipment to complete the work properly and in a timely manner, adequate staff with sufficient technical experience, and suitable financial status to meet the obligations of the contract.

E. The Audio-Visual Systems Contractor shall supply technicians who have received training from a nationally recognized training organization in the last 5 years on "speaker rigging methods" and "rigging safety".

F. An Electrical Contractor who does not meet the requirements listed above who intends to bid on this work shall be required to employ the services of a qualified Audio-Visual Systems Sub-Contractor. The Audio-Visual Systems Contractor must be named in the shop drawing submittal information along with written documentation verifying that the sub-contractor fulfills all requirements listed in 119690.

## 1.6 COORDINATION

A. Coordinate layout and installation of system components 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.

# PART 2 - PRODUCTS

## 2.1 EQUIPMENT

A. Refer to the Audio-Visual Drawings for all required equipment.

PART 3 - EXECUTION

## 3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used]. Conceal raceway and cables except in unfinished spaces.

B. Install plenum cable in environmental air spaces, including plenum ceilings.

C. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

## 3.2 INSTALLATION OF RACEWAYS

A. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

## 3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Cable Installation Requirements: All work shall be performed under the supervision of a Audio-Visual equipment supplier accredited by the factory of the system manufacturer. Satisfactory performance of the equipment shall be the responsibility of the equipment supplier. The final connections and shall be by the Audio-Visual Systems Contractor.
   1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
   2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
   3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
   5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

6. Precautions shall be taken to prevent electromagnetic and electrostatic hum pickup in the system wiring. For line level audio signals, float cable shields at the output of the source device. Shields not connected are to be folded back over the cable jacket and covered with heat shrink tubing for future use. Do not cut off unused shields.
7. Furnish and install minimum (1) one cable penetration EZDP33FWS, as manufactured by Specified Technologies, Inc. or equivalent, through fire rated partitions and floors, as indicated on the drawings.

C. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in equipment room spaces with terminating hardware and interconnection equipment.
2. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker level, line-level, microphone-level, control, video and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate parallel audio-visual system conductors from power runs by at least 12 inches. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.4 INSTALLATION

A. Bridged connections should be applied at microphone and line-level signal interfaces to maximize voltage transfer.

B. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

C. Mount equipment and enclosures plumb and square. Permanently installed equipment to be firmly and safely held in place, with extra safety cable used where possible. Design equipment supports with a minimum safety factor of five for any overhead loudspeakers. Provide speaker mounting hardware with ±5° adjustability from the specified aiming angle and perform such adjustments upon request without claim for additional payment.

D. Metallic speaker back boxes will be required on all ceiling or wall mount flush speakers.

E. Each cable shall be properly identified at each end using suitable wrap-around or other permanent labeling method. All cable numbers shall be marked on the record drawings for future reference.

F. Equipment Cabinets and Racks:
1. Group items of same function together and arrange controls symmetrically.
2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.

4. Provide engraved lamacoid or adhesive backed laminated labels on the front and rear of all active equipment mounted in the racks. Hand-written or embossed "ROTEX" or "DYMO" type labels shall not be accepted. Mark controls for easy operation by an operator unfamiliar with the system.

G. Limiter/Compressor: Program digital signal processors serving each speaker output with a limiter/compressor to avoid damage to speakers from system overloads.

H. Wall-Mounted Outlets: Flush mounted.

I. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

J. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

## 3.5 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Terminate equipment racks and other audio-visual equipment with properly grounded receptacles (no isolated grounds).

## 3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing the Audio-Visual systems, test for compliance with requirements.
3. Operational Test: Perform tests that include originating program at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
4. Acoustic Coverage Test: Measure system response to ensure variation of sound pressure levels in audience areas is plus or minus 2 dB.

B. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified

## 3.7 DEMONSTRATION

A. Owner's operating personnel in the proper set up, operating and maintenance procedures, installed under this contract, and shall include at least three (3) service calls of 4 hours minimum during the warranty period for service or instructions as required by the Owner, at a time mutually agreeable to the Owner and Contractor.

B. Provide minimum of two four-hour training sessions for system operation of the Blackbox Theater and two one-hour sessions for all other Audio-Visual systems.

**END OF SECTION 27 41 00**

# SECTION 27 53 13 – CLOCK AND TIME TONE SYSTEM

## PART 1 - GENERAL

### 1.1 GENERAL REQUIREMENTS & SCOPE

A. Furnish and install a complete new wireless clock and time tone distribution/paging system.

B. All bids shall be based on the equipment as specified herein. The catalog numbers and model designations are that of Sapling, Inc, Dukane, Peavey and Lowell. The specifying authority must approve any alternate system.

### 1.2 SUMMARY

A. This Section addresses the needs and requirements of the wireless clock system. It includes requirements for the wireless clock system components including, but not limited to, the following:
   1. Wireless Transceiver
   2. Wireless Repeater
   3. Secondary Analog Clock
   4. Time tone/paging system

### 1.3 SYSTEM DESCRIPTION

A. General: Furnish and install all equipment, accessories, and materials in accordance with these specifications and drawings to provide a complete and operating system.

### 1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract Sections:
   1. Submit equipment prints, full electronic wiring diagrams and specifications sheets for each item specified herein. Provide a tabulation of the specification clearly comparing the submitted item with the specified item, being able to refer to all written expressed functions and capabilities. Specification sheets shall be submitted on all items.
   2. Shop drawings detailing wireless clock
   3. Wiring diagrams, detailing wiring for power, signal, and control.
   4. Submit wiring diagrams showing typical connections for all equipment.
   5. Submit a certificate of completion of installation and service training.

### 1.5 QUALITY ASSURANCE

A. All items of equipment shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections.

B. The contractor shall be an established communications and electronics contractor that has had and currently maintains a locally run and operated business for at least three (3) years. The contractor shall utilize a duly authorized distributor of the equipment supplied for this project location with full manufacturer's warranty privileges.

C. The contractor shall show satisfactory evidence, upon request, that the supplier maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The supplier shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service the equipment being supplied.

D. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code" including, but not limited to:
   1. Article 250, Grounding.
   2. Article 300, Part A. Wiring Method.
   3. Article 310, Conductors for General Wiring.
   4. Article 725, Remote Control, Signaling Circuits.
   5. Article 800, Communication Systems.

E. Installation and start up of all systems shall be under the direct supervision of a local agency regularly engaged in installation, repair, and maintenance of such systems. The supplier shall be accredited by the proposed equipment manufacturers.

F. The agency providing equipment shall be responsible for providing all specified equipment and mentioned services for all equipment as specified herein. The agency must be a local authorized distributor of all specified equipment for single source of responsibility and shall provide documents proving such. The agency must provide written proof that the agency is adequately staffed with factory-trained technicians for all of the specified equipment. The agency must have established business for and currently be providing all services for the equipment.

G. The contractor shall guarantee availability of local service by factory-trained personnel of all specified equipment from an authorized distributor of all equipment specified under this section. Maintenance shall be provided at no cost to the purchaser for a period of one (1) year (parts and labor) from date of acceptance unless damage or failure is caused by misuse, abuse, neglect, or accident.

H. The contractor is responsible for all cost associated with proper installation, termination, configuration, programming, impedance and load matching of all system components.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products in factory boxes. Store in clean, dry space in original boxes. Protect products from fumes and construction traffic. Handle carefully to avoid damage.

## 1.7 IN-SERVICE TRAINING

A. The contractor shall provide training with this system. These sessions shall be broken into segments that will facilitate the training of individuals in the operation of this system. Operators Manuals and Users Guides shall be provided at the time of this training.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The manufacturer shall be:
   1. Sapling, Inc.
   2. Dukane Corporation
   3. Primex
   4. American Time

B. The intent of this specification is to establish a standard of quality, function and features. It is the responsibility of the bidder to insure that the proposed product meets or exceeds every standard set forth in these specifications.

C. The functions and features specified are vital to the operation of this facility, therefore, the acceptance of alternate manufacturers does not release the contractor from strict compliance with the requirements of this specification.

D. The contractor shall be responsible for providing a complete functional system including all necessary components whether included in this specification or not.

2.2 SYSTEM

A. The system shall have interface capability to GPS for time keeping stability.

B. The system shall be capable of working in 915-928 MHz frequency-hopping technology. The system shall be capable of automatic transmission of data along 51 alternating frequencies that allows for an enhanced signal, even if there is interference in one of the frequencies.

C. Each clock in the system shall be capable of receiving and transmitting the wireless signal which allows it to be used as a repeater while boosting the data stream and sending along the system. With this dual capability there shall be no limit on the number of clocks that can be used in the installation. The clock shall be designed to automatically work together without interference with each other. The system shall be capable of increasing the quality of the signal while increasing the quantity of the clocks.

D. The system shall include a master clock time tone system, tone generator and amplifier to send time tone signals to the speakers for class change.

E. The digital clock shall include automatic digital calibration for time base to minimize deviation from each other.

F. The analog clock shall have the capability for diagnostic function that will allow the user to view the quality of the signal, how long since the last time the clock received a signal, as well as functional tests of the electronics and the gears.

G. The system shall operate in a license-free frequency range where no license is required.

2.3 FCC APPROVAL

A. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a commercial installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
1. Reorient or relocate the receiving antenna.
2. Increase the separation between the equipment and receiver.
3. Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
4. Consult the dealer or an experienced radio/TV technician.

2.4 PRODUCT

A. Head end Clock Equipment
1. The wireless repeater transmitter shall be the Sapling STR 100-056-1. The repeater transmitter shall send correction signals to the SAL wireless analog clocks. The repeater transmitter shall utilize 915–928 MHz frequency–hopping technology and shall be FCC compliant, part 15 Section 15,247. The repeater transmitter shall receive a correction signal from a Sapling GPS-400-000-1 GPS clock receiver for constant time accuracy. Provide an RS-485 connected time tone master, Sapling model SMC200-00S-1 for time tone distribution signal control.
2. The supplied GPS antenna shall be mounted on the roof of the building. Provide roof penetrations and cable raceway to the headend location. The cable distance cannot exceed 75 feet in length.

B. Digital Clocks
1. The secondary clock shall be Sapling SBL Series wireless clock. The clock will be capable of receiving a signal from multiple clocks. The clock shall receive and transmit with 915–928 MHz frequency–hopping technology. The clock is to be capable of transmitting the time simultaneously without interfering with each other. The clocks shall include automatic calibration, as well as a diagnostic function that allows the user to view the quality of the signal, the last time the clock received a correction signal, a gearbox test and a comprehensive analysis of the entire clock. The clock shall have a maximum correction time of five (5) minutes. It shall be designed to be used with the Sapling Transceiver or the Sapling Repeater, which can be regulated via Sapling wireless communication protocol. Upon receipt of the wireless signal, the clock will immediately self–correct. The clock shall have a semi–flush smooth surface ABS case. Glass and visible molding marks are unacceptable. The clock shall have red numeral display. The clock shall be FCC compliant, part 15 Section 15,247. Provide Sapling SBL-103-254-1R, 2.5 inch digital clocks in general areas, SBL-103-404-1R, 4 inch high digital clocks with SBD-004-404-1 Surface Housing and wire guards in gymnasiums, and SBL-103-404-1R, 4 inch high digital clocks in Cafeteria and Media Center. 120 volt power shall be provided for the all clocks.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install system in accordance with applicable codes. Install equipment in accordance with manufacturer's written instructions.

B. Wiring Methods:
   1. Conceal wiring except in unfinished spaces.
   2. All new wiring on this project must be properly rated for the application.
   3. Cable to the new devices at new locations shall be installed in a neat and workmanlike manner, following the standard procedures used in the electrical contracting trade.
   4. Exposed wiring will not be permitted under any circumstances on this project.
   5. Any wiring, which is considered sloppy by the Engineer, shall be strictly unacceptable.
   6. Upon installation completion, a room-by-room test shall be conducted for every device in the system. A technician shall perform the test after school hours, and repairs shall be performed as needed at no cost to the Owner to any devices, which do not function correctly, including cable. A written room-by-room report following testing and repairs shall be prepared and submitted to the Engineer.

3.2 FIELD QUALITY CONTROL

A. Contractor Field Service:
   1. Provide services of a service representative for this project location to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.

B. Inspection:
   1. Make observations to verify that units and controls are properly labeled.

C. Testing:
   1. Rectify deficiencies indicated by tests and completely re-test work affected by such deficiencies at the Contractor's expense. Verify by the system test that the total system meets the specifications and complies with applicable standards.

3.3 COMMISSIONING

A. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of the system. Operators Manuals and Users Guides shall be provided at the time of this training.

B. Schedule training with Owner through the Architect, with at least seven (7) days advance notice.

3.4 CLEANING AND PROTECTION

A. Prior to final acceptance, clean system components and protect from damage and deterioration.

**END OF SECTION 27 53 13**

# SECTION 28 05 28 – PATHWAYS FOR ELECTRONIC AND SAFETY SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Pathways
   2. Hangers and supports
   3. Conduit and backboxes

A. Work Included:
   1. Furnish material, labor and services necessary for, and incidental to, installing the following systems where shown on the Plans and as hereinafter specified. Include all necessary work in the related sections of the Specifications to provide for complete systems.

### 1.2 ACTION SUBMITTALS

A. Not required

### 1.3 INFORMATIONAL SUBMITTALS

A. Not required

### 1.4 CLOSEOUT SUBMITTALS

A. Not required

### 1.5 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
   1. Division 26 – Electrical
   2. Division 28 – Electronic Safety and Security

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## PART 3 - EXECUTION

### 3.1 PATHWAYS

A. All cabling shall be as shown on plans, and per specifications.

B. Cabling may be run as open-type plenum rated cable concealed above lay-in ceiling spaces. Non plenum rated cabling shall be installed in conduit. Cabling shall be installed in conduit in all exterior locations and in all exposed or inaccessible locations including all open to structure, cloud ceilings, inside wall partitions or above drywall, wood, and other inaccessible ceilings.

C. Cabling may be run as open-type plenum rated cable concealed above lay-in ceiling space and exposed open to structure above or cloud type ceilings unless noted below. Cabling shall be installed above bar joist flanges to conceal cabling from view when routed through exposed ceiling. Non plenum rated cabling shall be installed in conduit. Cabling shall be installed in conduit in all exterior locations, all areas exposed below 8' A.F.F., and all inaccessible locations including inside wall partitions or above drywall, wood, and other inaccessible ceilings. Cabling shall be installed in conduit in the following spaces:

1. Electrical, Mechanical Equipment Rooms
2. Storage and Janitor Closets
3. Multipurpose Room
4. Auditorium/Theater
5. Stairwells
6. Restrooms
7. Tunnels

D. Cables shall be continuous from outlet to termination equipment.

E. Cables shall be terminated using tools recommended by the termination manufacturer.

F. Furnish and install a minimum of one (1) acoustical cable pathway device through all walls in which cable runs pass through. Device shall be Specified Technologies, Inc. NEZ44 or equivalent.

G. Furnish and install a minimum of (1) one cable pathway device through fire rated partitions and floors, and where indicated on the drawings. Device shall be Specified Technologies, Inc. EZDP33FWS, 3M QuickPass, or equivalent.

H. Refer to other divisions for fire sealing of penetrations through fire rated walls.

I. Provide access panels as necessary for cable routing.

### 3.2 HANGERS AND SUPPORTS

A. Cables shall be supported with "J-Hooks" a minimum of every four feet. Support devices are to be attached to existing permanent structure. J-Hooks must be located no more than 12" on each side of a change of direction.

B. Support devices are to be attached to existing permanent structure.

C. Cables shall be installed in cable tray where available.

D. Cables and supports shall be installed at a readily accessible location above ceilings.

## 3.3 CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

A. Furnish and install conduit rough-ins at all outlets locations where shown on drawings. Rough-in shall consist of a 4” square outlet box, single gang trim ring, and a minimum 1” conduit stubbed above an accessible ceiling to the nearest cable pathway. Plastic bushings shall be installed on both ends of conduit. Install blank covers on all unused rough-ins.

B. All conduits serving telephone/data communication outlets shall be 1” minimum. Conduits for all other system cable runs shall be sized for 40% maximum fill, or as shown on the drawings. Redundant paths shall be installed where fill exceeds 40%.

C. Provide pull strings in all conduits.

D. Conduit bends shall accommodate radius requirements of fiber cable as necessary.

## 3.4 GENERAL REQUIREMENTS

A. Under no circumstances shall cables be painted.

B. The contractor shall coordinate with MSU Networking and Telecommunications to accommodate the appropriate amount of time for all parties to complete activities.

C. Rough-ins *shall not* be daisy chained.

END OF SECTION 28 05 28

# SECTION 28 23 00 – VIDEO SURVEILLANCE SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
1. Cameras
2. Camera housings
3. Lenses
4. Heaters and power supplies

B. Work Included:
1. Section includes adding a new video surveillance system to the Art Annex, consisting of cameras, housings, data transmission wiring, and rough-in components. Cameras to terminate on owner provided Ethernet switches, located in the catwalk level IT room. Video surveillance head-end equipment will be in the IT rack.
2. Section includes adding an extension to the existing video surveillance system in Craig Hall, consisting of cameras, housings, data transmission wiring, and rough-in components. Video surveillance head-end equipment is existing and will remain.

### 1.2 DEFINITIONS

A. AGC: Automatic gain control.

B. IP: Internet protocol.

C. LAN: Local area network.

D. NTSC: National Television System Committee.

E. PC: Personal computer.

F. TCP: Transmission control protocol – connects hosts on the internet.

G. WAN: Wide area network.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings and finishes.

B. Shop Drawings: For video surveillance, include plans, elevations, sections, details and attachments to other work.

C. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.

E. Wiring Diagrams: For power, signal, and control wiring.

## 1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers installation instructions

B. Field quality-control reports.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section “Operation and Maintenance Data,” include the following:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

## 1.6 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. Comply with NECA 1.

C. Comply with NFPA 70.

## 1.7 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 40 to 100 deg. F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
2. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 10 to plus 120 deg. F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph. Use NEMA 250, Type 4 or IP66 enclosures.

## 1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fall in materials or workmanship within specified period.
   1. Warranty Period: One year from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 CAMERAS

A. Manufacturers: Avigilon (Motorola Solutions) with one (1) license for each new camera.

B. Camera 1 (CAM1)
   1. Manufacturer: Avigilon
   2. Model: 2.0C-H6A-D1
   3. Interior dome camera with 2.8-12mm lens.

C. Camera 2 (CAM2)
   1. Manufacturer: Avigilon
   2. Model: 4.0C-H6A-DO1-IR
   3. Outdoor IR dome camera with 4.4-9.3mm lens.

D. Camera 3 (CAM3)
   1. Manufacturer: Avigilon
   2. Model: 24C-H5A-3MH
   3. Outdoor triple head wide view camera.

E. Camera 4 (CAM4)
   1. Manufacturer: Avigilon
   2. Model: 10.0C-H5DH-DO1-IR
   3. Outdoor dual head camera with built-in IR.

## 2.3 SIGNAL TRANSMISSION COMPONENTS

A. Refer to Low Voltage Responsibility Matrix for more information.

## 2.4 SEISMIC PERFORMANCE REQUIREMENTS

A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI7.

B. 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.”

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Coordinate final camera location and desired viewing angles with Owner.

B. Coordinate location of LAN POE rated switch to be used with Owner.

C. Examine pathway elements intended for cables. Check supporting hooks, raceways and other elements for compliance with space allocations, installation tolerance, and other conditions affecting installation. Provide new surface raceway where needed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 WIRING

A. Comply with requirements in Division 26 Section “Raceway and Boxes for Electrical Systems.”

B. Wiring Method:
   1. Cables shall be supported with “J-Hooks” a minimum of every four feet. Support devices are to be attached to existing permanent structure. J-Hooks must be located no more than 12” on each side of a change of direction.
   2. Cables and supports shall be installed at a readily accessible location above ceilings.

### 3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Coordinate final rough-in location with owner prior to commencement of construction activities.

B. Install camera housings level and plumb.

C. Install cameras with 96” minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.

D. Install power supplies and other auxiliary components.

E. Identify system components, wiring, cabling, and terminals according to Division 26 Section “Identification for Electrical Systems.”

### 3.4 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. Assist

Owner with modifying their network camera monitoring system to view new camera installations as desired.

B. Tests and Inspections:
1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
   a. Prepare equipment list described in “Informational Submittals” Article.
   b. Verify operation of auto-iris lenses.
   c. Set back-focus of fixed local length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
   d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object distance appropriate for intended use of camera location. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
   e. Set and name all preset positions; consult Owner’s personnel.
   f. Set sensitivity of motion detection.

C. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days’ notice of test schedule.

D. Video surveillance system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

## 3.5 ADJUSTING

A. Occupancy Adjustment: When requested within 6 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner’s personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner’s use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

## 3.6 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses and monitor screens.

## 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 28 23 00

# SECTION 28 30 00 – FIRE DETECTION AND ALARM SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Fire alarm system

B. Work Included:
   1. Install a complete and operational addressable fire alarm system with live and recorded emergency voice communications as indicated by drawings, schedules, and riser diagrams. The system shall be connected to a UL Listed monitoring station which will notify the fire department and owners designated representative upon system activation. In jurisdictions required by ordinance to be UL Certificated per UL Category UUFX the documentation and UL Certificate shall be provided and posted at the job site.
   2. The equipment supplier must be the local factory authorized representative and must also be factory authorized, trained and certified to perform warranty service for the equipment being supplied providing local factory authorized service and spare parts inventory. The supplier or installer must be NICET Certified level II, III or IV and NICET certificate must be submitted with shop drawings.
   3. Equipment manufacturer shall be regularly engaged in manufacturer of fire alarm systems of types, sizes, and electrical characteristics required, and whose products have been in satisfactory use in similar service for not less than 5 years.
   4. Installer shall have at least 5 years of successful experience on projects with fire alarm systems work similar to that required for this project and be a licensed contractor.
   5. For a period of one year from date of Owner's first beneficial use, the system shall be under a no charge warranty/service contract, as authorized by the manufacturer. During that period, replacement components and labor shall be readily available during standard business hours. After the one-year guarantee period, the supplier warrants that he is capable of providing service on a 24 hour, 7-day a week basis for at least five (5) additional years.

### 1.2 SUBMITTALS

A. Provide shop drawings in accordance with the appropriate paragraphs the applicable version of NFPA 72 for the following items:
   1. Written narrative providing intent and system description.
   2. Floorplan layout showing location of all devices, including isolation components to comply with the applicable NFPA 72 chapter on the Performance of Signaling Line Circuits (SLCs) referencing fault tolerances and manufacturer’s specific product requirements, strobe candela ratings, speaker taps, control equipment, supervising station equipment. Include point of compass (north arrow), scale used, room use identification and building features that will affect installed devices such as shelving or floor mounted equipment such as kitchen equipment.
   3. Sequence of operation in a matrix form.

4. Equipment data sheets.
5. Battery and voltage drop calculations.
6. Mounting elevations of wall mounted equipment.
7. Wiring pathway diagrams.
8. Provide NICET level II, III or IV (minimum) certificate of individual responsible for the design and calculations of the fire alarm system.
9. Manufacturers published instructions including operation and maintenance manuals. (Hard copy of information shall be left with owner)
10. Record of Completion, per applicable NFPA 72. (Hard copy of information shall be left with owner)
11. Site specific software in the form of a thumb drive.
12. Record (as built) drawings. (Hard copy of information shall be left with owner)
13. Completed record of inspection and testing per NFPA 72 (Hard copy of information shall be left with owner)

B. Submittals shall be submitted in two packages; the first package shall include items 1-7 and 13. Package two shall include items 8-12 submitted after project is completed. Partial submittal packages may be returned as rejected without being reviewed.

C. Engineered sealed fire alarm drawings prepared by fire alarm supplier required for permit application are the responsibility of the Contractor and fire alarm system supplier. Coordinate any system design drawing submission requirements with the Engineer.

## 1.3 REFERENCES, RELATED SECTIONS of the SPECIFICATIONS

A. Requirements of the following Sections of the Specifications apply to Work for this Section:
   1. Division 26 – Electrical
   2. Division 28 – Electronic Safety and Security

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

## 2.2 MANUFACTURERS

A. Simplex 4100ES

## 2.3 PRODUCTS

A. Fire Alarm Control Panel
   1. The Fire Alarm System will be microprocessor based, non coded, and utilize addressable devices with integrated or adjacently mounted voice controls. It will be electronically

supervised, common signaling, individual device indicating, with remote central station monitoring. The system shall operate from manual fire alarm stations, smoke detectors, thermal detectors, duct smoke detectors, water flow, and tamper switches.

2. The panel shall include an integral 80 character LCD display that can be viewed without opening the front cover of the control panel. Located within the panel or adjacently mounted to the panel there shall be a microphone, speaker selection switches and voice control equipment including amplifiers and audio message generators. Systems specified without selectable speaker zones (general alarm) shall not require speaker selection switches. See paragraph I Sequence of Operations for requirements.
3. The panel shall include SLC loop modules for a minimum of 198 addressable points. Addressable points shall include at a minimum 99 modules such as relays, monitor points and manual stations and 99 addressable detectors such as smoke, heat or CO. Additional loop modules or loop capacity must be provided to assure 40% spare addresses for any type of device added to the system.
4. The system shall transmit alarm signals to a remote central station in full compliance with NFPA 72. The batteries will be able to operate the system under maximum normal load condition for not less than 24 consecutive hours followed by fifteen (15) minutes of alarm.
5. Provide a low voltage, 24 volt DC fire alarm control panel including all circuitry, amplifiers, power supplies, batteries, programming and cabinet space necessary to perform required functions, and to service as test and trouble signal points.
6. All input/output cards shall be modular, plug in type devices.
7. Equip control panel for number of initiating addresses as required plus 40% spare capacity. Provide 25% spare amplifier capacity.
8. The control panel shall include the following additional features:
    a. Walk test feature for single person testing of the system. This feature includes special audible indication and zone trouble indication.
    b. Alarm verification, programmable per device.
    c. Totally field programmable with multiple password protection.
    d. All initiation and indication circuits shall be power limited for use with limited energy cables.
    e. Addressable monitor modules may be field programmed for normal water flow or supervisory operation.
    f. Any output control/relay module circuit may be mapped to any input device in non volatile program memory.
    g. Display program function allows system field program information to be easily displayed using front panel controls.
    h. Disable capability for each device shall be provided from the control panel.
    i. A 1000 event history log stored in non volatile memory with storage of alarm verification activities.
    j. Serial annunciator port shall be provided for high-speed 4-wire annunciation of the system.
9. Contractor to provide dedicated 20A, 120VAC power connections to fire alarm control panel, amplifier cabinets and fire alarm strobe extender power panels.
10. Provide and install clamp-on breaker locking cleats manufactured by Brady, Space Age Electronics, or equivalent for all breakers serving the fire alarm system components. Each breaker shall be labeled with a red identifier noting “fire alarm”. Coordinate with Division 26 contractor.

B. Integrated Fire Alarm Communicator:

1. The FACP shall include a UL Listed integrated commercial fire digital communicator complete with 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. Connections for two 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. The digital communicator shall be connected to the fire alarm system to receive and transmit alarm signals, trouble conditions and supervisory conditions using Contact ID transmission protocol.
2. The system shall include a dual path commercial fire alarm communicator with cellular and IP communication capabilities (Honeywell #IPGSM-4G or equal). The Contractor shall provide cable, connectors and installation of IP data cables from the data rack. The communicator will transmit each event as digital information over the IP and cellular network. The contractor shall test the signal of the cellular antenna and provide additional antennae as required to produce a reliable cellular signal.

C. Remote Annunciator/Remote Microphone
1. Remote annunciator panel shall include an 80-character backlit LCD display to mirror the fire alarm control panel display and piezo sounder to notify of system trouble. Provide a microphone with speaker selector switches in the same enclosure with the remote annunciator or a general remote paging microphone as specified in section I Sequence of Operations.
2. Remote annunciator/microphone to be provided with key lock switch and control keypad for system acknowledge, audible signal silence, system reset functions and speaker zone selection if specified in paragraph I Sequence of Operations.
3. Flush or surface mounting of remote annunciator panel to be coordinated prior to installation.

D. Field Devices
1. Manual Fire Alarm Stations: Addressable non coded, red semi flush, dual action manual station manufactured of Lexan with clearly visible operating instructions on the cover. Where noted on drawings, provide a Safety Technology International Stopper II cover without horn.
2. Photoelectric Detectors: Addressable photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density. Provide detectors as shown on plans and as a minimum provide a smoke detector at control panel and each remote power supply location.
3. Duct Detector: Addressable photoelectric duct mounted smoke detector with sampling tube and protective housing. Provide remote test switches or remote LED’s where noted on plans. Contractor to provide all load relays necessary for fan shut-down. Note: When using a duct smoke detector to activate the closure of a fire/smoke damper, the damper shall close any time the air distribution fan serving the respective duct is not running. This may be accomplished by directly monitoring the fan status or BAS interface. Coordinate with mechanical engineer for proper interface.
4. Thermal Detector: Addressable fixed temperature low profile device with twist lock base. Temperature rating to be 135 degrees or 190 degrees (High temp version). In elevator

equipment rooms and shafts, heat detectors shall be located within two feet of each sprinkler head.

5. Relay Modules: Addressable relay modules with LED indicator light.
6. Control Modules: Addressable control modules with LED indicator light.
7. Monitor Modules: Addressable monitor modules with LED indicator light.
8. Door Holders: Flush wall mount electromagnetic door holder controlled by fire alarm system. Provide extension rods or box extensions as necessary. Door Holders shall be 24V or 120V powered. Provide power supplies as necessary. Label power supplies “Door Holder Power Supply”. Door Holders provided by Door Hardware Supplier or Door Holders provided by fire alarm supplier. At the contractors option provide either 24 volt or 120 volt door holders for this project.
9. Beam Detector Open Area: {choose one beam detector type} Multi beam smoke detector shall support as many as seven emitters placed within the field of view of a single imager, each placed at different heights. The imager's large viewing angles, both horizontal and vertical, enable three-dimensional area coverage for design flexibility and additional deployment savings. The detector is a combined transmitter/receiver unit that can be directly connected to a conventional FACP zone input or to an addressable/intelligent FACP using monitoring modules. Provide with multi angle surface mounting kit (if required based on required mounting angles) and remote test switches where noted on plans.
10. Beam Detector Reflective: {choose one beam detector type} Single ended beam smoke detector allows the detector to find and lock onto a standard reflector, automatically set the detector sensitivity, track the reflector, resulting in the elimination of nuisance alarms due to building movement. The detector is a combined transmitter/receiver unit that can be directly connected to a conventional FACP zone input or to an addressable/intelligent FACP using monitoring modules. Provide with multi angle surface mounting kit (if required based on required mounting angles) and remote test switches where noted on plans.
11. Carbon Monoxide Detector: Provide an addressable CO detector that looks similar to an addressable smoke detector. The detector shall be connected to the SLC circuit and include an audible base providing a code 4 temporal pattern. If addressable CO detectors are unavailable by the specific system supplier a 4-wire carbon monoxide detector monitored by a fire alarm system monitor module with local alarm sounder and trouble relay will be considered equal. Mount per manufacturer’s instructions.
12. All initiating devices shall be identified with a black-on-clear (1/4” text minimum) printed adhesive label affixed to the device. This label shall include the device address.

E. Signaling Appliances

1. Speakers. Speakers shall be combined with strobes or stand alone as indicated on plans. Speakers shall be wall or ceiling mounted and white in color.
   a. All speakers shall operate on 25 VRMS or with field selectable output taps from 0.25 to 2.0 Watts.
   b. Speakers in corridors and public spaces shall produce a minimum nominal sound output of 83 dBA at 10 feet (3m).
   c. Frequency response shall be a minimum of 400 HZ to 4000 HZ.
   d. The back of each speaker shall be sealed to protect the speaker cone from damage and dust.
2. Strobes. Strobes shall be wall or ceiling mounted and white in color. Strobes shall be combined with speakers or stand alone as indicated on plans. Strobe lights shall be multi-

candela units and meet the requirements of the ADA, UL Standard 1971, be fully synchronized, and shall meet the following criteria:

a. The maximum pulse duration shall be 2/10 of one second.
b. Strobe intensity and flash rate shall meet the requirements of UL 1971.
c. Strobes shall be synchronized.
d. The signals shall operate on 24 VDC polarized and the device shall be able to test circuit supervision without disconnecting wires.
e. There shall be FIRE lettering clearly visible from both sides. Red or white device color to be coordinated with Architect.
f. Visual and audible devices shall be synchronized within the project area and synchronized with all adjacent areas. This Contractor and equipment supplier shall provide cabling and equipment to achieve synchronization between the project area and adjacent spaces- including but not limited the installation of synchronization modules, Sync Protocols, replacement of power supplies, replacing strobes without synchronization capability, and associated cabling. Locating existing power supplies outside the project area shall be the responsibility of the Contractor/equipment suppliers.

3. Provide remote strobe signal expander power supplies as necessary. Provide dedicated 20A, 120V circuit to each remote power supply or group of power supplies not exceeding 80% of AC circuit capacity.

F. Waterflow Exterior Signaling Appliances

1. Potter SASH -120 volt exterior audible/visual alarm signal representing sprinkler system activation.
   a. Device shall operate on 120 volt and connected to a set of contacts from the main waterflow switch.
   b. Device shall be outdoor rated and include verbiage identifying a “sprinkler alarm” and call 911.

## PART 3 - EXECUTION

### 3.1 SYSTEM WIRING

A. All wiring will be as required by the Equipment Supplier. Wire color-coding and the color shall remain the same throughout the system. In general, all initiating devices such as manual stations, smoke detectors and all modules will be installed across a common #18AWG twisted unshielded pair or as required by system supplier. The strobe circuits shall require #14AWG unshielded or as required by system supplier. The speaker circuits shall require #16AWG shielded cable or as required by system supplier.

B. No conduit or raceway system will include Class I or non-power limited fire protection signaling circuits with Class II or power limited fire protection signaling circuits in accordance with N.E.C. Article 725 or 760.

C. All conduit and wiring to flow switches, tamper switches, etc., shall be furnished and installed as part of this work.

D. Test results shall be submitted to Engineer per this specification section.

E. Wiring may be run as concealed open type plenum rated cable. Exposed or inaccessible wiring shall be installed in conduit. Where possible wiring/conduit shall be concealed. Provide sleeves in all walls which cable runs pass through. Refer to 26 05 29 for fire sealing of penetrations through fire rated walls. Provide access panels as necessary for cable routing. Support devices are to be attached to existing permanent structure.

## 3.2 SEQUENCE OF OPERATIONS

A. Fire alarm system shall evacuate entire building in the event of an alarm. The evacuation signal shall begin with a pre-announce tone in a code 3 temporal pattern repeated 3 times followed by the evacuation message. The message shall repeat until silenced or overridden by operators at the FACP or remote annunciator/microphone station with live voice instructions. Evacuation message shall be approved by the AHJ.

##DEFINE EVACUATION ZONES##

B. The following will occur upon activation of any alarm initiating device (smoke detector, heat detector, manual pull station and water flow monitor module):
1. Sound audible signals and flash visual signals.
2. Display alarm status information on the fire alarm control panel, each remote annunciator and send an alarm signal to the remote supervising station.
3. Activate addressable control modules to shut down air handling units, close fire/smoke dampers and release all smoke doors.
4. Upon elevator lobby, elevator equipment room or elevator shaft detection, primary or alternate recall module contacts will close to activate elevator recall. Upon equipment room or shaft detection, an additional control module contact will close for a signal to the elevator cab.
5. Upon activation of elevator hoist way or elevator equipment room heat detectors the elevator power shunt trip fusible switch shall be caused to trip open.
6. Activate auditorium egress lighting.

C. The following to occur upon activation of a trouble signal (open circuit, ground fault, low battery, loss of AC power, etc.):
1. Display trouble status at the fire alarm control panel, each remote annunciator and send a trouble signal to the remote supervising station.

D. A system duct detector activation shall shut-down all air handling units, display supervisory status at the fire alarm control panel, each remote annunciator and send a supervisory signal to the remote supervising station.

OR

E. Tamper switch state change shall display supervisory status at the fire alarm control panel, each remote annunciator and send a supervisory signal to the remote supervising station

F. Exterior horn/strobe at fire department connection to only activate on water flow.

G. Kitchen hood fire detection to initiate full building alarm equal to the activation of a manual station or smoke detector.

H. Carbon monoxide detector activation shall display supervisory status at the fire alarm control panel, each remote annunciator and send a supervisory signal to the remote supervising station

I. The fire pump to be monitored by the fire alarm system to send alarm signals to the fire alarm control panel for 'Pump Running', and supervisory signals for 'Phase Reversal' and 'Pump Power Source'. The emergency feeder overcurrent device position shall be monitored and produce a trouble signal if open.

## 3.3 EXISTING FIRE ALARM SYSTEM AND FIRE PROTECTION SYSTEM DISTURBANCE

A. When adding or deleting fire alarm devices care must be taken to assure the existing system will continue to work if an alarm, trouble or supervisory event occurs. When deleting existing addressable devices the address must be deleted or temporarily disabled in the program before the completion of work on any given day. When adding new devices the address must be programmed or temporarily disabled before the completion of work on any given day. Signaling appliances added to any system must maintain parallel supervised wiring with the end of line device in-tact before the completion of work on any given day. Only if all parties agree (owner, and AHJ) that the fire alarm system shall be out of service overnight shall a system be allowed to be placed in an out of service condition.

B. Where fire protection is reworked/removed from the construction site, The Division 28 contractor shall furnish and install heat detectors in all areas of construction. Heat detector coverage shall be reworked as required in the event construction barrier changes occur or construction phase changes. The Contractor and an approved equipment supplier of the system manufacturer shall include all necessary programming changes to install and remove heat detectors.

**END OF SECTION 28 30 00**

## SECTION 31 10 00 – SITE CLEARING

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Clear site of plant life and grass.

B. Remove:

1. Trees and shrubs where indicated.
2. Root system of trees and shrubs.
3. Surface debris.
4. Vegetation.

C. Perform clearing and grubbing operations.

D. Protect benchmarks; repair damage to all areas outside contract limits to match specified new work.

### 1.2 RELATED WORK

A. Specified Elsewhere:

1. Section 02 41 00 – Site Demolition
2. Section 31 23 16 – Excavation
3. Section 31 25 00 – Erosion & Sedimentation Control

### 1.3 REGULATORY REQUIREMENTS

A. Conform to all applicable local, state, and federal codes for disposal of debris.

B. Coordinate all site clearing work with the utility companies.

### 1.4 REFERENCES

A. Conform to the applicable portions of Sections 201 and 202 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all Supplemental Specifications and Recurring Special Provisions.

### 1.5 PROJECT CONDITIONS

A. Conduct removals to minimize interference with adjacent building areas. Maintain protected egress and access at all times.

B. Provide, erect and maintain temporary traffic control and security devices in accordance with the standard details and drawings included in the contract documents.

C. Do not close or obstruct roadways and sidewalks without permits and Owner approval.

D. Accept premises as found. Neither Owner, nor Engineer assumes responsibility for condition of areas or continuation of areas in condition existing at or after date of bidding documents.

### 1.6 SUBMITTALS (RESERVED)

## PART 2 – PRODUCTS (RESERVED)

## PART 3 – EXECUTION

### 3.1 CLEARING

A. Clear designated areas for access to site and execution of work.

B. Remove designated trees and shrubs, grass, weeds and other vegetation. Grub out stumps, roots, rocks, and obstructions which interfere with installation of new work.

C. Clear undergrowth and deadwood, without disturbing subsoil.

**3.2 PROTECTION**

A. Protect plant growth and features remaining for final landscaping.

B. Protect bench marks and existing work from damage or displacement.

C. Maintain designated site access for vehicle and pedestrian traffic.

D. Protect existing active utility lines during construction.

E. Utility lines encountered during construction that are not scheduled to be removed must be protected, relocated, or scaled and capped by appropriate trades having jurisdiction.

F. Protect all existing items not indicated to be removed.

**3.3 REMOVAL**

A. Remove all waste materials from the Owner's property and legally dispose of same.

B. All topsoil shall be stockpiled onsite or at a location as approved by the Owner. Any excess topsoil shall be removed from the project site and properly disposed of off-site.

C. Do not store debris, remove as it accumulates. If Contractor fails to remove debris promptly, the Engineer reserves the right to cause same to be removed at Contractor's expense. Debris may not be burned or buried on the site.

D. Provide all measures of protection required by state authorities, regulations, and laws for protection of surrounding property, sidewalks, curbs, the public and all employees during removal operations. Measures taken, including sidewalks, sheds (if required), barricades, warning lights and signs, and rubbish chute (if required), shall be in strict accordance with the American Standard Building Construction A10-2-1944 and all applicable state and federal laws. Provide all protection as required by codes having jurisdiction and maintain until no longer necessary.

**3.4 CLEAN UP**

A. Upon completion of work remove tools, materials, apparatus, debris and rubbish of every sort. Leave premises clean, neat and orderly.

**END OF SECTION 31 10 00**

## SECTION 31 22 13 – ROUGH GRADING

### PART 1 – GENERAL

#### 1.1 WORK INCLUDES

A. Excavate subsoil and stockpile for later reuse. Remove excess from site.

B. Grade and rough contour site improvement areas.

#### 1.2 RELATED WORK

A. Specified Elsewhere:

1. All Sections of Division 31 and 32.

#### 1.3 SUBMITTALS

A. Accurately record location of remaining, rerouted or new utilities by horizontal dimensions, elevations or inverts, and slope gradients on Contract Documents.

B. Submit test results of compaction testing – See Section 31 23 23 - Fill.

#### 1.4 REFERENCES

A. Conform to the applicable portions of Division 200 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway, including all Supplemental Specifications and Recurring Special Provisions.

B. Project Geotechnical Report and its recommendation will be made available to the bidders/contractors.

a. The report is provided to contractors for reference and information.
b. There may be perceived or real deviation or conflict between the report, its recommendations and Contract Documents; if so contact Engineer for direction.

#### 1.5 PROTECTION

A. Protect existing trees, shrubs, lawns and other features remaining as portion of final landscaping.

B. Protect benchmarks, existing structures, fences, roads, sidewalks, paving, curbs and all other items to remain.

C. Protect above- or below-grade utilities which will remain.

D. Protect work from damage caused by settlement or movement caused by rough grading.

E. Repair damage.

### PART 2 – PRODUCTS

#### 2.1 MATERIALS

A. Subsoil: Excavated material (other than topsoil) which is graded free of lumps larger than 6 inches, rocks larger than 3 inches and debris.

### PART 3 – EXECUTION

#### 3.1 PREPARATION

A. Identify specified lines, levels, contours and data.

B. Identify known below grade utilities. Stake and flag locations.

C. Identify and flag above grade utilities.

D. Maintain and protect existing utilities remaining which pass through work area.

E. Notify Utility Companies to remove and relocate necessary utilities.

F. Upon discovery of unknown utility or concealed conditions, discontinue affected work and notify the Engineer immediately. Confirm notification in writing.

G. Visit the site and become familiar with all existing conditions under which work is to be performed.

**3.2 DEWATERING**

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout or damage by rain or water accumulation.

C. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

**3.3 SUBSOIL EXCAVATION**

A. Excavate subsoil from areas to be re-landscaped or regraded and stockpile in area designated on site. Remove excess subsoil not being reused from Project site.

B. Excavate and remove all organic, loose or obviously compressive materials. The subgrade shall then be proof-rolled until the grade offers an unyielding surface and until the specified compaction is achieved; refer to Section 31 23 23 - Fill. Areas of excessive yielding shall be excavated and backfilled with clean, compacted soil that meets the approval of the Engineer.

C. Do not excavate wet subsoil.

D. Stockpile subsoil to depth not to exceed 4 feet.

E. When excavating through roots, perform work by hand and cut roots with a sharp axe.

**3.4 TOLERANCES.**

A. Top surface of subgrade: Plus or minus 1 inch.

**3.5 TESTING AND COMPACTION.**

A. Refer to Section 31 23 23 - Fill.

**END OF SECTION 31 22 13**

# SECTION 31 23 16 – EXCAVATION

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Excavating for sewers, pavements, sidewalks, curbs and gutter and incidental work.

B. Removal and off-site satisfactory disposal of unstable and unsuitable materials.

### 1.2 RELATED WORK (RESERVED)

### 1.3 REGULATORY REQUIREMENTS

A. Codes and Standards:

1. Conform to the applicable portions of Section 203 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all Supplemental Specifications and Recurring Special Provisions.

2. Prior to the commencement of construction, the Contractor shall be aware of, and become familiar with applicable local, state and federal safety regulations, including the current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

3. Additionally, the Contractor shall be aware that slope height, slope inclination and excavation depths (including utility trench excavations) should in no case exceed those specified in local, state or federal safety regulations.

### 1.4 COORDINATION

A. Do not interrupt existing utilities serving facilities occupied and used by Owner or others except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided. Provide minimum of 48-hour notice prior to enacting an approved temporary interruption.

### 1.5 SUBMITTALS (RESERVED)

## PART 2 – PRODUCTS (RESERVED)

## PART 3 – EXECUTION

### 3.1 EXAMINATION

A. Site Information

1. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that Owner will not be responsible for interpretations or conclusions drawn there from by Contractor. Data are made available for convenience of Contractor.

2. Contractor shall be responsible for determining the actual ground water elevation and soil conditions at the specific site prior to commencing with the excavation. It may be expedient to drill auger holes, excavate test pits or make additional soil borings at or adjacent to the construction area immediately prior to construction to determine the prevailing soil conditions and water table elevation. It is the Contractor's responsibility to make auger holes, excavate test pits or make additional soil borings, as he deems appropriate to determine the ground water and soil conditions that will be encountered. Additional test borings and other exploratory operations made by the Contractor shall be at no cost to the Owner.

### 3.2 PREPARATION

A. Establish extent of excavated areas.

B. Identify and set required lines, levels and contours.

C. Maintain benchmarks, monuments and other reference points.

D. Before starting excavation, establish location and extent of underground utilities occurring in work area. Contact Joint Utility Locating Information for Excavators (J.U.L.I.E.) (800) 892-0123 or all other utility companies on the project site which are not members of this system.

## 3.3 EXCAVATION

A. General

1. Excavation consists of removal and redistribution of material encountered when establishing required grade and subgrade elevations, including stripping of topsoil.

2. The Contractor is solely responsible for designing and constructing stable excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. All excavations shall comply with applicable local, state and federal safety regulations including the current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

3. All sheeting, shoring and bracing of trenches, pits and excavations shall be the sole responsibility of the Contractor.

4. Construction site safety is the sole responsibility of the Contractor, including but not limited to, the means, methods, and sequencing of construction operations.

5. Earth excavation consists of stripping of topsoil, removal and disposal of pavements and other obstructions visible on ground surface, underground structures and utilities indicated to be demolished and removed, material of any classification indicated in data on sub-surface conditions, and other materials encountered that are not classified as unauthorized excavation.

B. Unauthorized Excavation

1. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, only when acceptable to the Engineer. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of the same classification, unless otherwise directed by Engineer.

C. Additional Excavation

1. When excavation has reached required sub-grade elevations, notify Engineer who will make an inspection of conditions. If unsuitable bearing materials are encountered at required sub-grade elevations, carry excavations deeper and replace excavated material as directed by Engineer. Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to change in work.

D. Dewatering

1. Prevent surface water and subsurface or ground water from flowing into excavation and from flooding project site and surrounding area.

2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering

system components necessary to convey water away from excavations.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage

1. Stockpile satisfactory excavated materials in the location designated by the Engineer or Owner, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain. Contain excavated silt/soil runoff with silt fences in accordance with Local, State and Federal Requirements.

F. Excavation Near Utilities

1. Protect, support, shore, brace, etc. all utility services uncovered by excavation.

2. Accurately locate and record abandoned and active utility lines rerouted or extended, on Contract Documents.

3. Repair damaged utilities to the satisfaction of the Utility Owner.

G. Disposal of Excess and Waste Materials

1. Removal from Owner's Property

a. Remove waste materials, trash and debris and legally dispose of it off Owner's property.

2. Excess Material

a. Excess excavated material shall be removed from the site and properly disposed of.

H. Topsoil

1. Topsoil shall be stripped from site so that all organic materials, stumps, and roots are removed from the site.

2. Contractor shall stockpile sufficient clean topsoil onsite for reuse and shall dispose of all excess or unsuitable material in accordance with existing state and federal regulations.

3. Temporary topsoil stockpiles shall be temporarily stabilized as required.

**3.4 FIELD QUALITY CONTROL**

A. The Contractor shall allow bearing surfaces at the bottom of excavations to be inspected by the Engineer, and shall modify the bearing surfaces as requested by the Engineer, prior to placement of any base materials.

B. Proofrolling. Subgrades shall be proofrolled to detect areas of insufficient compaction. Proofrolling shall be accomplished by making minimum of 2 complete passes with fully-loaded tandem-axle dump truck with a maximum weight of 20 tons, or approved equal, in each of 2 perpendicular directions while under the supervision and direction of the independent testing laboratory. Areas of failure shall be excavated and recompacted as specified herein. Continual failure areas shall be stabilized at no additional cost to Owner. Subgrade exposed longer than 48 hours or on which precipitation has occurred shall be re-proofrolled.

**3.5 PROTECTION**

A. Stability of Excavation

1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible either because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

B. Cold Weather Protection

1. Protect excavation bottoms against freezing when atmospheric temperature is less than 35$^{O}$F (1$^{O}$C).

C. Protection of Persons and Property

1. Fence and barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights during hours from dusk to dawn each day and as otherwise required by authorities having jurisdiction.

2. Protect structures, landscaping, utilities, sidewalks, pavements or other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

3. Comply with current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

**END OF SECTION 31 23 16**

# SECTION 31 23 23 – FILL

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Preparation of subgrade for pavements, sidewalks and curb and gutters.

B. Backfill for site utilities.

C. Fill for over-excavation.

D. Consolidation and compaction of all fill material.

### 1.2 RELATED WORK

A. Specified Elsewhere:

1. Section 31 23 16 – Excavation
2. Section 32 12 16 – Asphalt Paving
3. Section 32 13 13 – Concrete Paving

### 1.3 REFERENCE TO STANDARDS

A. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/$ft^3$).

B. ASTM D4253 - Maximum Index Density and Unit Weights of Soils Using a Vibratory Table.

C. Missouri Department of Transportation (MoDOT): Standard Specifications for Highway, Latest Edition.

D. Project Geotechnical Report and its recommendation will be made available to the bidders/contractors.

a. The report is provided to contractors for reference and information.
b. There may be perceived or real deviation or conflict between the report, its recommendations and Contract Documents; if so contact Engineer for direction.

### 1.4 REGULATORY REQUIREMENTS

A. Conform to the applicable portions of Sections 203 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all Supplemental Specifications and Recurring Special Provisions.

### 1.5 SUBMITTALS

A. Submit copies of Standard Proctor Density Test results to Engineer a minimum of seven business days prior to backfilling any excavations.

### 1.6 QUALITY ASSURANCE

A. Compaction Testing

1. Standard Proctor Density Testing and Compaction Testing of fill materials and inspection of subgrades and fill layers will be performed by the Contractor’s testing service, using Proctor information furnished by the Contractor.

2. If, in opinion of Engineer, based on testing service reports and inspection, subgrade or fills, which have been graded or placed on-site are below specified density, provide additional compaction and testing at no additional expense to the Owner.
3. When, during progress of work, tests indicate that compacted materials will not meet specifications, remove defective work, replace and retest at no additional cost to the Owner.

4. Ensure that all compacted fills are tested before proceeding with placement of surface materials.

**1.7 FIELD TESTS**

A. Compaction Tests

1. Contractor shall make arrangements with an independent laboratory for completing compaction tests and shall pay for those tests. They shall also make arrangements with testing firm to have sufficient number of personnel from the testing laboratory and testing equipment in good working order during <u>all</u> placement and compaction operations. Name of testing firm chosen by Contractor shall be submitted to Engineer for approval prior to beginning of backfilling. Engineer reserves right to reject testing firm at any time during construction and to require another testing firm to perform tests.

**1.8 PROTECTION**

A. Protect and avoid all existing underground utilities during construction operations. Repair of any utilities damaged by construction shall be the responsibility of the respective Contractor.

**PART 2 – PRODUCTS**

**2.1 DEFINITIONS**

A. Suitable Soil

1. Suitable soil is a soil having less than 5% organic matter by weight as determined by the Loss on Ignition Test (determine weight loss caused by heating sample to 500º C for 6 hours after drying in accordance with ASTM D-2216, "Laboratory Determination of Moisture Content of Soil").

B. Unsuitable Soil

1. Unsuitable soil is a soil that contains 5% or more organic matter as determined by the Loss of Ignition Test previously specified, rubbish, vegetable matter of every kind, roots, and boulders larger than 5 inches in dimension which might interfere with the proper bonding to adjacent contact surfaces, or as otherwise determined unsuitable by the Engineer.

C. Cohesive Soil

1. Cohesive soil is a soil containing more than 50 percent fine material passing the No. 200 standard sieve, and with more than 15 percent clay-size particles smaller than 0.002 mm (2 microns). The soil matrix passing the No. 40 standard sieve exhibits dry (crushing) strength in the dry state and cohesive shear strength in the moist state, as well as being plastic in the moist state.

**2.2 ENGINEERED FILL MATERIALS**

A. General

1. Fill material shall be as recommended by the geotechnical engineer as denoted in the Fill Material Types table in the Geotechnical Engineering Report for the project. Material should be approved by geotechnical engineer. Existing undocumented fill, if used for engineered or structural fills, should be approved by the materials testing firm. This material should be removed and recompacted if used as an engineered or structural fill as described in the geotechnical report.

2. Engage a qualified independent testing laboratory to test materials from on-site and off-site sources to test materials for conformance to this specification. The name of the testing laboratory shall be submitted to the Engineer for review prior to conducting any tests. Results of tests shall be submitted to the Engineer for review prior to engineered fill material being placed.

## 2.3 TRENCH BACKFILL MATERIALS

A. General Fill and Cohesive Backfill

1. Provide acceptable soil materials for backfill, free of clay lumps, rock or gravel larger than two inches in dimension, debris, waste, frozen materials, vegetable and other deleterious matter.

B. Granular Backfill and Trench Backfill

1. Granular backfill shall consist of MoDOT Type 1 or Type 5 aggregate. Granular backfill shall be used under steps, stoops, walks, roads, parking lots and against structure walls. (Minimum 4-inch depth below walks, steps, etc.).

# PART 3 – EXECUTION

## 3.1 EXAMINATION

A. Prior to placement of any fill or backfill and prior to placement of all subsequent fill lifts, contact Engineer for inspection and testing of excavation subgrade and testing of each compacted layer of fill and backfill material. Provide proctor information necessary for the Engineer to perform density testing on in-place backfill material.

## 3.2 PREPARATION

A. Backfilling and compaction shall not occur until the following conditions are satisfied:

1. Acceptance by Engineer of construction below finish grade.

2. Inspection, testing, approval and recording locations of underground utilities.

3. Removal of concrete formwork.

4. Removal of trash and debris, vegetation, snow or ice, water, unsatisfactory soil materials, obstructions and deleterious materials.

5. Removal of shoring and bracing and backfilling of voids with satisfactory material.

6. Ensure that ground surface within excavated area to be backfilled is not frozen.

7. When existing ground surface has a density less than that specified under Article 3.3-C of this Section for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content and compact to required depth and percentage of maximum density. The Contractor shall be required to proofroll native soils as recommended in the geotechnical report prior to placing fill materials.

## 3.3 BACKFILLING AND COMPACTING

A. General

1. Place acceptable soil material in layers to required subgrade elevations, for each area classification listed below.

a. In existing turf areas, use satisfactory excavated or borrow exterior fill material.

B. Placement and Compaction

1. Place backfill, base and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand operated tampers. Heavy equipment including compaction equipment shall not operate within 2 feet of unbraced substructure walls.

2. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen or contain frost or ice.

3. Place backfill and fill materials evenly adjacent to structure to required elevations. Take necessary precautions to prevent wedging action of backfill against structures by carrying the material uniformly around structure to approximately same elevation in each lift.

C. Percentage of Maximum Density Requirements

1. Unless otherwise noted on the plan sheets, all fill material shall be compacted to not less than 95% of ASTM D698, Standard Proctor Compaction Test or as otherwise recommended in the project geotechnical report. All utility trenches shall be compacted to 8% of ASTM D698.

D. Moisture Control

1. Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water top surface or subgrade or layer of soil material, to prevent free water appearing on surface during or subsequent to compaction operations. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

E. Grading

1. General

a. Uniformly grade areas within limits of excavation under this Section, including adjacent transition areas. Compact with uniform levels or slopes between such points and existing grades.
b. Remove stones over 1-1/2" in any dimension and sticks, roots, rubbish and other extraneous matter.

c. Rough grade to 6" - 12" below finish, grades and elevations indicated in the drawings.

d. Grading Outside Structure Lines

1. Grade areas adjacent to building lines to drain away from structures and to prevent ponding.

2. Finish surfaces free from irregular surface changes, and as follows:

a. Slabs: Shape surface of areas under slabs to line, grade and cross-section, with finish surface not more than 1/2" above or below required subgrade elevation.

2. Grading Surface of Backfill Under Walks and Slabs.

a. Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/4” when tested with a 10’ straightedge.

3. Compaction

a. After grading, compact subgrade surfaces to the depth and percentage of maximum or relative density for each area classification.

F. Maintenance

1. Protection of Graded Areas

a. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

b. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

2. Reconditioning Compacted Areas

a. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.

3. Settling

a. Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality and condition of surface or finish to match adjacent work and eliminate evidence of restoration to greatest extent possible.

## 3.4 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction

1. Allow the Engineer to inspect subgrades and fill layers before further construction work is performed.

2. If in opinion of Engineer, based on field density testing and inspection, subgrade or fills which have been placed are below specified density, provide additional compaction and testing at no additional expense to the Owner.

**END OF SECTION 31 23 23**

**Section 31 25 00 – Erosion & Sedimentation Control**

**PART 1 - GENERAL**

**1.1 WORK INCLUDES**

A. Installation of temporary and permanent erosion and sedimentation control systems.

B. Installation of temporary and permanent slope protection systems.

**1.2 RELATED WORK**

A. Specified Elsewhere:

1. Section 02 41 00 – Demolition

**1.3 ENVIRONMENTAL REQUIREMENTS**

A. Protect adjacent properties; any identified endangered or threatened species and/or critical habitat, any identified cultural or historic resources, and receiving water resources from erosion and sediment damage until final stabilization is achieved. All storm water controls and systems must be installed & functioning as designed and free of accumulated sediment and debris before final project approval.

**PART 2 - REFERENCE TO STANDARDS**

**2.1 City of Springfield, MO**

**2.2 Missouri Department of Natural Resources.**

**PART 3 - PRODUCTS**

**3.1 MATERIALS**

A. Sod, and ground covers for the establishment of vegetation in accordance with Division 32.

B. All erosion control products, sediment control devices, or materials for non-storm water BMPs as specified herein and on the Construction Drawings.

C. Rolled erosion control products according to Erosion Control Technology Council (ECTC) standard specifications.

C. Temporary mulches such as loose straw or wood cellulose.

E. Temporary and permanent outfall structures as specified on the drawings.

**3.2 SUBMITTALS**

A. Contractor shall submit shop drawings or material certifications for all manufactured erosion and sediment control materials.

**PART 4 - EXECUTION**

**4.1 PREPARATION**

A. Review the drawings and Storm Water Pollution Prevention Plan.

C. Conduct storm water pre-construction meeting with Site Contractor, all ground-disturbing Sub-contractors, site engineer of record or their representative who is familiar with the site, and state or local agency personnel if available.

D. Revise Erosion Control Plan as necessary to address potential pollution from site identified after issuance of the Erosion Control Plan at no additional cost to owner.

## 4.2 EROSION AND SEDIMENTATION CONTROL AND SLOPE PROTECTION IMPLEMENTATION

A. Place erosion and sediment control systems in accordance with the drawings or as may be dictated by site conditions to maintain the intent of the specifications and permits.

B. Site Maps shall be corrected or modified as site conditions change. Contractor must obtain approval from Owner's Engineer prior to modifying or substituting Best Management Practices. Changes during construction shall be noted in the site plans.

C. Owner has authority to limit surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and embankment operations and to direct Contractor to provide immediate permanent or temporary pollution control measures.

D. Maintain erosion and sedimentation control systems as dictated by site conditions, indicated in the construction documents, or as directed by governing authorities or Owner to control sediment until final stabilization. Contractor shall respond to maintenance or additional work ordered by Owner or governing authorities immediately, but in no case, within not more than 48 hours at no additional cost to the Owner.

E. Contractor shall incorporate permanent erosion control features, permanent slope stabilization, and vegetation into project at earliest practical time to minimize need for temporary controls.

F. Permanently stabilize cut and fill slopes as construction proceeds to extent considered desirable and practical.

G. Disturbed areas that will not be graded or actively worked for the time frame established in the plans, shall be temporarily stabilized as work progresses with vegetation or other acceptable means in accordance with Division 32 or as otherwise shown on the plans unless otherwise specified in the Contract Documents. In the event it is not practical to seed areas, slopes must be stabilized with mulch and tackifier, bonded fiber matrix, netting, blankets or other means to reduce the erosive potential of the area.

H. Contractor shall adhere to all the terms and conditions as shown on the plans and contained in the Missouri Department of Natural Resources General Permit and SWPPP.

I. Contractor shall provide a qualified personnel, in accordance with the attached SWPPP, to inspect disturbed areas of the construction site that have not been finally stabilized, as required by the Missouri Department of Natural Resources General Permit, at least once every seven (7) calendar days and within twenty-four (24) hours of the end of a storm that is 0.5 inches or greater or equivalent snowfall.

**END OF SECTION 31 25 00**

## SECTION 31 63 29 - 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, testing and inspecting, and other items for complete drilled-pier installation.

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.

C. Trial Drilled Pier: Same unit price as indicated for drilled pier, including backfilling.

### 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.

C. Shop Drawings: For concrete reinforcement, detailing fabricating, bending, supporting, and placing.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

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

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 TRIAL DRILLED PIER

A. Trial Drilled Pier: Construct trial drilled pier of diameter and depth and at location indicated or, if not indicated, of same diameter and depth as largest drilled piers, located at least three diameters clear of permanent drilled piers, to demonstrate Installer's construction methods, equipment, standards of workmanship, and tolerances.

1. Install reinforcement, fill with concrete, remove temporary casings, and terminate trial drilled pier 24 inches below subgrade and leave in place.
2. Install permanent casings, excavate bell, excavate rock socket, and place slurry, as required for permanent drilled piers.
3. If Architect determines that trial drilled pier does not comply with requirements, excavate for and cast another until it is accepted.

## 1.10 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 Owner no fewer than five days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Owner'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. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
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, 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, 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. Supplement with the following:

a. Fly Ash: ASTM C 618, Class C or Class F.
b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregate: ASTM C 33/C 33M, graded, 3/4-inch-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.

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, 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 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.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

D. Proportion normal-weight concrete mixture as follows:

1. Compressive Strength (28 Days): See plans.
2. Maximum Water-Cementitious Materials Ratio: See plans.
3. Minimum Slump: Capable of maintaining the following slump until completion of placement:

    a. 4 inches for dry, uncased, or permanent-cased drilling method.
    b. 6 inches for temporary-casing drilling method.
    c. 7 inches 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, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, 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 indicated 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.
4. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.

E. Notify and allow 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 indicated 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: Probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.

1. Test first three drilled piers and one of every six drilled piers thereafter.
2. Fill auger-probe holes with grout.

G. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.

H. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches 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**,** or leave temporary casings in place.

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 PERMANENT STEEL CASING INSTALLATION

A. Install permanent steel casings of diameter not less than diameter of drilled pier.

1. Install casings as excavation proceeds, to maintain sidewall stability.
2. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
3. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
4. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
5. Fill annular void between casing and shaft wall with grout.

B. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.

1. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

## 3.4 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.

## 3.5 CONCRETE PLACEMENT

A. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified testing agency.

1. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.

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 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 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 head of concrete above bottom of casing.

1. Vibrate top 60 inches 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, 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 to maintain delivered temperature of concrete at no more than 90 deg F.

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.

**3.6 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 placement.

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 indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities are determined by testing and inspecting agency. Final evaluations and approval of data are determined by Architect.

   a. Bearing Stratum Tests: Testing agency takes undisturbed 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 and below and 80 deg F 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.
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. Bell dimensions and variations from original design.
17. Date and time of starting and completing excavation.
18. Inspection report.
19. Condition of reinforcing steel and splices.
20. Position of reinforcing steel.
21. Concrete placing method, including elevation of consolidation and delays.
22. Elevation of concrete during removal of casings.
23. Locations of construction joints.
24. Concrete volume.

25. Concrete testing results.
26. Remarks, unusual conditions encountered, and deviations from requirements.

**3.7 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**

SECTION 319113- SOIL PREPARATION

PART 1- GENERAL

1.01 DESCRIPTION

A. This Section includes materials, labor, apparatus, tools, equipment, temporary construction, transportation, and services necessary for and incidental to performing the proper completion of Work, as required to make a complete and thorough preparation of the planting soil, including soil amendment products, imported topsoil, as required, to make up deficiencies in quantity of soil available on site, as shown in the Contract Drawings, and as specified herein this Section.

B. Work under this Section consists of, but is not necessarily limited to, furnishing and installing the following:

1. Agronomic Soil Fertility Testing and Soil Percolation Testing.
2. Topsoil.
3. Pre-Plant Weed Control.
4. Soil Conditioners, Amendments and Fertilizers (Organic & Chemical).

C. Related Work:

1. Section 31 2000: Earthwork
2. Section 32 9300: Exterior Plants
3. Section 32 8400: Irrigation Systems
4. Section 32 9200: Turf Grasses

1.02 DEFINITIONS AND APPLICABLE STANDARDS

A. References:

1. USDA- United States Department of Agriculture
2. ASTM- American Society for Testing Materials.

B. Definitions:

1. Topsoil - Shall be friable soil, providing sufficient structure in order to give good tilth and aeration to the soil. Topsoil shall be free of roots, clods, stones larger than one-inch (1”) in the greatest dimension, pockets of coarse sand, noxious weeds, sticks, lumber, brush and other litter. It shall not be infested with nematodes or other undesirable disease-causing organisms such as insects and plant pathogens.

2. Gradation Limits - Soil shall be a sandy loam, loam, clay loam or clay. The definition of soil texture shall be per the USDA classification scheme. Gravel over ¼-inch in diameter shall be less than 20% by weight.

3. Permeability Rate - Hydraulic conductivity rate shall be not less than one-inch (1”) per hour, nor more than twenty-inches (20”) per hour, when tested in accordance with the USDA Handbook Number 60, Method 34b, or other approved Methods.

4. Fertility - The range of the essential elemental concentration in soil shall be as follows: (cont. next page)

| Ammonium Bicarbonate/<br>DTPA Extraction (PPM) | | |
|---|---|---|
| Element | Concentration of elements for Soil Selection, measured as mg/kilogram dry weight basis | Concentration of Elements for Final Acceptance (amended and conditioned soil) measured as mg/kilogram dry weight basis |
| Phosphorus | 2 - 40 | 10 – 40 |
| Potassium | 40 - 220 | 100 – 220 |
| Iron | 2 - 35 | 24 – 35 |
| Manganese | 0.3 - 6 | 0.6 – 6 |
| Zinc | 0.6 - 8 | 1 – 8 |
| Copper | 0.1 - 5 | 0.3 – 5 |
| Boron | 0.2 - 1 | 0.2 – 1 |
| Magnesium | 50 - 150 | 50 – 150 |
| Sodium | 0 - 100 | 0 – 100 |
| Sulfur | 25 - 500 | 25 – 500 |
| Molybdenum | 0.1 - 2 | 0.1 - 2 |

5. Acidity - The soil pH range measured in the saturation extract (Method 21a, USDA Handbook Number 60) shall be 6.0 – 7.9.

6. Salinity - The salinity range measured in the saturation extract (Method 3a, USDA Hand Number 60) shall be 0.5 – 2.0 dS/m. If calcium and if sulfate ions both exceed 20 milli-equivalents per liter in the saturation extract, the maximum salinity shall be 4.0 dS/m.

7. Chloride - The maximum concentration of soluble chloride in the saturation extract (Medoth3a, USDA Handbook Number 60) shall be 150 mg/1 (parts per million).

8. Boron - The maximum concentration of soluble boron in the saturation extract (Method 3a, USDA Handbook Number 60) shall be 1 mg/1 (parts per million).

9. Sodium Adsorption Ratio (SAR) - The maximum SAR shall be 3 measured per Method 20b, USDA Handbook Number 60.

10. Aluminum – Available aluminum measured with the Ammonium Bicarbonate/DTPA Extraction shall be less than 3.0 parts per million.

11. Soil Organic Matter Content - Sufficient soil organic matter shall be present to impart good physical soil properties but not be excessive to cause toxicity or cause excessive reduction in the volume of soil due to decomposition of organic matter. The desirable range is 3% to 5%. The carbon:nitrogen ratio should be about 10. A high carbon:nitrogen ratio can indicate the presence of hydrocarbons or non-humified organic matter.

12. Calcium Carbonate Content - Free calcium carbonate (limestone) shall not be present in acid-loving plants.

13. Heavy Metals - The maximum permissible elemental concentration in the soil shall not exceed the following concentrations: (cont. on next page)

| Ammonium Bicarbonate/ DTPA Extraction (PPM) | |
|---|---|
| Element | (mg/kilogram) dry weight basis |
| Arsenic | 1.0 |
| Cadmium | 1.0 |
| Chromium | 10.0 |
| Cobalt | 2.0 |
| Lead | 30.0 |
| Mercury | 1.0 |
| Nickel | 5.0 |
| Selenium | 3.0 |
| Silver | 0.5 |
| Vanadium | 3.0 |

a. If the soil pH is between 6 and 7, the maximum permissible elemental concentration shall be reduced 50% to the above values. If the soil pH is less than 6.0, the maximum permissible elemental concentration shall be reduced 75% of the above values. No more than three (3) metals shall be present at 50% or more of the above values.

14. Phytotoxic constituent, herbicides, hydrocarbons, etc. – Germination and growth of plants shall not be restricted more than 10% compared to the reference soil. Total petroleum hydrocarbons shall not exceed 50 mg/kg dry soil measured per the modified EPA Method No. 8015. Total aromatic volatile organic hydrocarbons (benzene, toluene, xylene and ethylbenzene) shall not exceed 0.5 mg/kg dry soil measured per EPA Method No. 8020.

15. Sub Grade - Soil level resulting from the rough grading work under another Section. Cultivation of sub grade areas prior to placement of Topsoil is included in this Section.

16. Stockpiled Topsoil - Soil stockpiled for spreading over prepared sub-grade.

17. Stockpiled Native Topsoil - Topsoil stripped from the site prior to rough grading Work (under another Section), to be spread and amended as Work under this Section.

18. Imported Topsoil - Off-site Topsoil, imported and stockpiled under this Section, to be spread and amended as Work under this Section.

C. Measurements

1. PPM: Measurement, in parts per million.

1.03 QUALITY ASSURANCE

A. Installer Qualifications for requirements indicated herein this Section:

1. Licensed Landscape Contractor, in the State of Arkansas.

a. Engage an experienced, licensed Contractor who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.

b. Installer's Field Supervision: Contractor shall maintain an experienced, full-time landscape supervisor/superintendent at the Project Site during times that landscaping operations identified herein the Contract are in progress.

B. Manufacturer's Directions: Follow Manufacturer's directions and drawings in cases where the Manufacturers of articles used in this Section furnish directions covering points not shown in the Contract Drawings or Contract Specifications.

C. Permits, Fees, Bonds, Testing, and Inspections: Contractor shall arrange and pay for permits, fees, bonds, testing, and inspections necessary to perform and complete his portion of the Work.

D. Approved Testing Laboratory and Procedures for Agronomic Soil Fertility Analyses:

1. Agronomic Soil Fertility Analyses shall be conducted by a reputable, certified, agronomic soils laboratory. Laboratory shall be a member of the Council on Soil Testing and Plant Analysis. The same laboratory shall be used throughout the duration of the Contract.

2. Contractor shall verify and confirm the selected Testing Laboratory and specific location(s) of soil sample(s) with the Landscape Architect prior to commencing soil sampling operations.

3. For each Soil type, submit the physical Soil Samples directly to the selected Laboratory for analysis, per the procedures outlined per Part III herein this Section.

   a. In addition to the physical Soil Samples, Contractor shall also provide the Laboratory with a copy of the Soil Amendment and Fertilizer products indicated herein this Section.

4. Along with the testing data results, the Agronomic Soil Fertility Analysis shall also include written recommendations authored by the Laboratory conducting the Analyses for amending, treating, and/or correcting the sampled soils. Laboratory shall utilize the organic-based Soil Amendments and Fertilizers described herein this Section to the greatest extent possible to produce satisfactory planting soil(s) suitable for sustaining healthy viable plant growth.

   a. The Analyses shall also include Maintenance and Post-Maintenance fertilization programs for planted areas within the Contract

5. Agronomic Soil Fertility Analyses shall be performed on each Soil Type samples, and include testing results for the following:

| |
|---|
| pH: |
| Electro-conductivity (salinity) measurement – saturated extract. |
| Measurement of sodicity (Sodium Absorption Ratio); |
| Estimate of soil texture and soil organic matter; |
| Presence of lime; |
| Nutrients/Toxic Elements measurement of DPTA extract |
| Saturation extracts for nitrate, sulfate, sodium, calcium, magnesium, potassium, soluble phosphate, and boron; |
| Parasitic nematodes; |
| Herbicide contamination; |
| (For Lightweight Soil Mixes): Test for physical and chemical composition, and saturated weight per cu.ft. |

6. Planting operations shall not commence until the results of the Agronomic Soil Fertility Analysis and Recommendations are reviewed accordingly by the Landscape Architect.

7. The quantity or type of amendments may be modified by the Landscape Architect within fourteen (14) days of receipt of the results. The Agronomic Soil Fertility Analysis and Recommendations shall take precedence over the amendment and fertilizer application rates specified herein or on the Contract Documents.

8. The Agronomic Soil Fertility Report/Recommendation shall take precedence over the amendment and fertilizer application rates specified herein or on the Contract Documents.

1.04 SUBMITTALS

A. General:

1. Collect information into a single Submittal for each element of construction and type of product or equipment identified under this Section for review.

2. Submittal Format: As applicable, furnish Submittal as a single electronic digital PDF (Portable Document Format) file.

B. Digital Submittal Information:

1. Product/Material Data: Submit available product/material literature supplied by manufacturer's, indicating that their products comply with specified requirements. Provide manufacturing source (name, address, and telephone number), and distributor source (name, address, and telephone number) for each type of product/material.

   a. Planting Soil (Imported/Amended Topsoil).

   b. Soil Amendments (for each type used, for Sand, Perlite, Peat Humus, Gypsum, Soil Sulfur, Iron, etc).

   c. Bulk Composted Organic Soil Amendment Material.

   d. Granular Soil Conditioning Material.

   e. Mycorrhizal Inoculum.

   f. Fertilizers (for each type used).

2. Agronomic Soil Fertility Analysis and Recommendations: Submit a minimum of fourteen (14) days prior to amending of the soil and ordering soil amendments. The locations of where each of the soil test samples were derived from the Project Site shall be keyed to the site plan and shall be included with the results.

3. Qualification Data: Submit names for firms and persons specified in the "Quality Assurance and Control" Article to demonstrate their capabilities and experience on similar installations.

C. Material Samples: Submit four (4) sets of physical Material Samples for review of kind, color, pattern, size, and texture for a check of these characteristics with other elements, and for a comparison of these characteristics between Submittal and actual component as delivered and installed. Include the full range of exposed color and texture expected in the completed work. Provide Material Samples bound and individually wrapped in re-sealable labeled 1-gallon plastic bags (as applicable):

1. Provide Material Sample sets for each item submitted under Product/Material Data.

D. Submittals under this Article will be rejected without the benefit of review by the Landscape Architect if they are difficult to read due to insufficient scale, poor image quality, or poor drafting quality; or if the required information is missing or not presented in the format as requested.

E. No Work shall proceed under this Section until Submittal requirements indicated herein have been reviewed accordingly by the Landscape Architect.

1.05 DELIVERY, STORAGE, AND HANDLING

A. General: Deliver and install materials so as to not delay Work and install only after preparations for installation have been completed.

1. Packaged Materials: Deliver packaged materials in original, unopened packages or containers, with manufacturer's labels intact and legible, showing weight, analysis, and name of manufacturer. Store and secure properly to prevent theft or damage.

a. Store packaged materials off ground and under cover, away from damp surfaces and inclement weather.

b. Protect during storage and construction against soilage or contamination from earth and other materials.

2. Bulk Materials:

a. Deliver and store bulk materials so as not to impede Work of others.

b. Do not dump or store bulk materials near structures, utilities, walkways, and pavements, or on existing turf areas, or plants.

c. Protect storage and construction against soilage or contamination from earth and other materials. Provide adequate separation between bulk materials so as not to cross-contaminate bulk materials.

d. Store under cover, away from inclement weather.

e. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water run-off, and airborne dust reaching adjacent properties, water conveyance systems, structures, or walkways.

f. Accompany each delivery of bulk materials (fertilizers, amendments, topsoil, etc.) with appropriate certificates. Furnish original certificates to Landscape Architect upon request.

1.06 COORDINATION, SCHEDULING, AND OBSERVATIONS

A. Notify the Contractors performing Work related to installation of Work under this Section in ample time to allow sufficient time for them to perform their portion of Work and that progress of Work is not delayed. Verify conditions at the Project Site for Work that affects installation under this Section. Coordinate items of other trades to be furnished and set in place.

B. Utilities: Determine location of above grade and underground utilities and perform Work in a manner which will avoid damage to utilities. Hand excavate, as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.

C. Excavation: When conditions detrimental to adequate Soil Preparation operations are encountered, such as rubble fill, adverse drainage conditions, or obstructions, cease operations and notify Landscape Architect for further direction.

D. Installation: Perform Soil Preparation operations only when weather and soil conditions are suitable in accordance with locally accepted practices.

E. Construction Site Observations: Periodic site observations shall be made by the Landscape Architect during the installation of Work under this Section for compliance with requirements for type, size, and quality. Landscape Architect retains right to observe Work for defects and to reject unsatisfactory or defective material at any time during progress of Work. Contractor shall remove rejected materials immediately from Project site, all associated cost are to be paid by the contractor.

1.07 SITE CONDITIONS

A. Project Site shall be free of weeds, native grasses, evasive grasses, (Bermuda Grass, Johnson Grass, Nut Grass, etc.) prior to Topsoil distribution or soil amendment placement.

B. Excessive rock, dead or declining vegetation, trash, debris, or other items that has accumulated throughout the duration of the Project shall be removed from the Project Site by the Contractor, and as directed by the Landscape Architect.

C. Grading and soil preparation Work shall be performed only during the period when beneficial and optimum horticultural results may be obtained. If the moisture content of the soil should reach such a level that working it would destroy soil structure or cause compaction, spreading and grading operations shall be suspended until, in the opinion of the Landscape Architect, the moisture content is increased or reduced to acceptable levels and the desired results are likely to be obtained.

1. Soil moisture level prior to planting shall be no less than 75% of field capacity. The determination of adequate soil moisture for planting shall be in the sole judgment of the Landscape Architect.

2. If the soil moisture level is found to be insufficient for planting, planting pits shall be filled with water and allowed to drain before commencing planting operations.

D. Planting areas which become compacted in excess of 85% relative compaction due to construction activities shall be tilled and thoroughly cross-ripped to a minimum depth of twelve-inches (12”) to alleviate the condition, taking care to avoid all existing subsurface utilities, drainage, etc.

**PART 2- PRODUCTS**

2.01 PLANTING SOIL (TOPSOIL)

A. Topsoil: Meet ASTM D5268, pH range of 5.5 to 7, 4 percent organic material minimum.

1. Topsoil Source: Reuse native surface soil stockpiled on the site. Verify suitability of native surface soil stockpiled on site to produce Topsoil meeting requirements; amend, as necessary. Supplement native surface soil stockpiled on site with imported Topsoil when quantities are insufficient.

a. Composition: Fertile, friable, well-drained soil, of uniform quality, free of stones over one-inch (1”) diameter or larger in any dimension sticks, oils, chemicals, plaster, concrete, roots, plants, sod, and other deleterious or extraneous materials harmful to plant growth.

b. Obtain an Agronomic Soil Fertility Report/Recommendation of the stockpiled Topsoil from the approved Testing Laboratory indicated herein this Section.

c. Test Results: Request Testing Agency to send one (1) copy of test results direct to the Landscape Architect and one (1) copy to the Owner. Amend as required.

2. Topsoil Source: Provide Imported Topsoil obtained from off-site sources, from naturally well-drained sites; do not obtain from bogs or marshes.

a. Quantity: Provide Imported Topsoil as soon as an insufficient quantity of native stockpiled surface soil is verified. Quantity of Imported Topsoil to complete the Work shall be calculated by Contractor.

b. Stockpiling: Stockpile on site as directed by Owner.

c. Composition: To match in quality, accepted native stockpiled Topsoil.

d. Analysis: Obtain an Agronomic Soil Fertility Report/Recommendation of the Imported Topsoil from the approved Testing Laboratory indicated herein this Section.

e. Review: Landscape Architect reserves the right to take samples of the Imported Topsoil delivered to the site for conformance to the Contract Specifications.

f. Rejected Imported Topsoil: Immediately remove rejected Imported Topsoil off site, at Contractor's expense.

2.02 SOIL MIXES/BLENDS (BACKFILL/PLANTING MIX)

A. Soil Conditioner Blend, for amending on-site native soil planting surfaces, stockpiled, plant back fill or imported topsoil: Furnish a thoroughly blended composition of Bulk Composted Organic Soil Amendment Material and Granular Soil Conditioning Material & Fertilizer. Any substitution for the “Soil Conditioner Blend” listed herein must be requested by the Contractor and approved, in writing, by the Landscape Architect at least thirty (30) days prior to installation.

1. Bulk Composted Organic Soil Amendment Material:

a. Material Composition: Bulk Composted Organic Soil Amendment Material shall be thoroughly cured for a minimum of 100 days, and shall be free from any trash (glass, metal, plastic, etc.) deleterious materials, bio-solids, and/or toxic chemicals. The Material shall be non-hazardous, and conform to US Environmental Protection Agency 40 CFR503 criteria for “Class A” products. It shall also exceed standards and specifications for unrestricted application as a landscaping and agricultural soil amendment.

b. Humus material shall have an acid-soluble ash content of no less than 6% and no more than 20%. The organic matter content shall be at least 50% on a dry weight basis.

c. Types of acceptable products are composts, manures, mushroom composts, straw, alfalfa, peat mosses etc. low in salts, low in heavy metals, free from weed seeds, free of pathogens and other deleterious materials.

d. Composted wood products are conditionally acceptable [stable humus must be present]. Wood based products are not acceptable which are based on red wood or cedar.

e. Sludge-based materials are not acceptable.

1) Gradation/Screen Analysis: A minimum of 90% of the material by weight shall pass a ½” screen. Material passing the screen shall meet the following criteria:

| Percent Passing | Sieve Designation |
|---|---|
| 80 – 100% | 6.35 mm (1/4”) |
| 50 – 80% | 2.38 mm (No.8) |
| 0 – 40% | 500 micron (No.35) |

2) Maturity: Physical characteristics suggestive of maturity include shall include:

a) Color: Dark brown to black.

b) Odor: Aerobic, without malodorous presence of decomposition products.

c) Particle characterization: Identifiable wood pieces are acceptable, but the balance of Material should be soil-like without recognizable grass or leaves.

d) Analytical Properties: Contractor shall submit proof of the Bulk Composted Organic Soil Amendment Material by providing a sample as identified herein this Section, and a lab analysis that has been performed within 30 days of the installation of the planting. Soil mix shall have (at a minimum) the following properties:

| Material | Minimum Targeted Property/Range |
|---|---|
| Total Nitrogen (N%) | .50-1.0% |
| Phosphorus (as P2O5) | 2.0% |
| Potassium (as K2O) | 0.2% |
| pH (units) | 6.0 to 7.5, as determined in saturated paste. |
| Organic Content | Minimum 50% based on dry weight and determined by ash method. Minimum 205 lbs. organic matter per cubic yard of compost. |
| ECe (millimho/cm) | <5.0; based on pre-leaching with equal volume of water. |
| Carbon-to-Nitrogen Ratio | <25-to-1, nitrogen stabilized. |
| Bulk Density | 1,000 to 1,100 pounds/cubic yard. |
| Sodium Absorption Ratio (SAR) | Under 20.0 |
| Total Iron | 1.5% - 3.0% |
| Moisture Content | 35%-60% |
| Acid-soluable Ash content | No less than 6% and no greater than 20%. |
| Salt Content | <10millimho/cm @ 25d C. on a saturated paste extract. |
| Boron Content | <1.0 parts per million on a saturated paste extract. |
| Silicon-Content (acid-insoluable ash) | <50% |
| Calcium Carbonate | No presence on alkaline soils. |
| Maximum Total Permissible Pollutant Concentrations Parts per million (mg/kg dry-weight basis) | • Arsenic: 1.0<br>• Cadmium: 1.0<br>• Chromium: 10.0<br>• Cobalt: 2.0<br>• Copper: 1.0<br>• Lead: 30.0<br>• Mercury: 1.0<br>• Molybdenum: 2.0<br>• Nickel: 5.0<br>• Selenium: 1.0<br>• Silver: 0.5<br>• Vanadium: 3.0<br>• Zinc: 2.0 |

e) Application Rate: As indicated herein this Section under “Planting Soil Amendments Schedule”.

f) Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

2. Granular Soil Conditioning Material & Fertilizer:

a. Material Composition and Analytical Properties: Granular Soil Conditioning Material & Fertilizer shall be a singular manufacturer-blended combination of soil conditioning material and fertilizer. It shall be granular in form, long-lasting, free flowing, and suitable for application with approved equipment. It shall not contain any sewage sludge or manure-based products, and shall contain the following guaranteed minimum available analysis range:

| Element/Material | Targeted Property Range |
|---|---|
| Nitrogen (N) | 5.0% to 6.0% |
| Phosphoric Acid (as P2O5) | 2.0% to 3.0% |
| Potash (as K2O) | 1.0% to 4.0% |
| Humic Acids | 15.0 % to 20.0% |
| Calcium | 7.0% |
| Sulfur | 0.0% to 5.0% |

b. Commercial-Grade Products, Manufacturers and Associated Rates of Application: Subject to compliance with requirements.

1) Provide submittal and sample to be approved by the Landscape Architect.

B. Washed Plaster Sand: Clean, washed, natural or manufactured sand, sharp, fine-textured, free of toxic materials. Sieve tested in accordance with ASTM C136, with 100% passing through a #4 screen, 0% passing through a #200 screen.

1. Chemical Properties: (by DPTA Saturation Extract Method):

a. Soluble Salts/Salinity: Maximum conductivity of 3.0 millimhos/cm at 25 degrees C.

b. Boron: Maximum concentration of 1.0 PPM.

c. Sodium Absorption Ratio (SAR): Maximum 6.0.

d. pH: 7.0.

C. Perlite: Horticultural Perlite, soil amendment grade, 6.5 to 7.5 pH.

1. Unacceptable Materials: Polystyrene beads shall not be used as a substitution for horticultural Perlite.

D. Vermiculite: Horticultural Vermiculite, gold-brown in color.

1. Size: 2-4mm, 5 mesh to 10 mesh sieve size.

2. Density: 4.5 to 5.5 lb./cu ft.

3. Grade: #2, Medium Grade.

2.03 INORGANIC PLANTING SOIL AMENDMENTS

A. Peat Humus:

1. Type: Canadian Sphagnum Peat, as derived from the genus Sphagnum, medium-divided, coarse fibrous texture, brown in color.

2. Measurement: Measure peat in air dry condition, containing not more than 35% moisture by weight on an "as-received" basis.

3. Physical Properties:

| Percent Passing | Sieve Designation |
|---|---|
| 95 – 100% | 9.51 mm (3/8") |
| 0 – 40% | 500 micron (No.35) |

4. Organic Content (dry weight basis): Minimum 95%.

5. Fiber Content: Greater than 66%.

6. Water Holding Capacity: 20x to 30x its dry weight in water.

7. Range in Ash Content (%): 1.0 to 5.0.

8. Chemical Properties:

   a. Nitrogen (dry weight basis): 0.6-3.0%.

   b. Salinity/Soluble Salts: Saturation extract conductivity 0.0-3.0 millimhos/cm @ 25 degrees C.

   c. pH range: 3.0 to 4.0.

9. Unacceptable Materials:

   a. Coir Dust.

   b. Sedge Peat.

   c. Reed Peat.

   d. Hypnum Peat.

B. Mycorrhizal Inoculum:

1. Mycorrhizal Inoculum for Plant Material: Dual soil-conditioning biological inoculum system of endo- and ecto- Mycorrhizal, used to further aid the plants ability to efficiently uptake available soil nutrients and increase resistance to drought.

   a. Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

      1) 7-gram Myco-Pak, Tri-C Enterprises LLC, Chino, CA, 800-927-3311.

      2) 4 oz. Packet - Roots 1 Step, Roots, Inc., Independence, MO, 800-342-6173.

      3) Or equal, as approved by the Landscape Architect.

   b. Provide at the prescribed application rate, per the Manufacturer's written recommendations.

2.04 CHEMICAL AMENDMENTS AND COMPONENTS

A. General: Chemical Soil Amendment Components listed herein may or may not be used, depending on the results of the Agronomic Soil Fertility Report. Provide as required.

B. Gypsum: Commercially-processed and packaged agricultural-grade hydrated calcium sulfate product ($CaSO_4$), 92.0% minimum, pH at 7.1.

1. Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Ben Franklin® No. 1 Agricultural Gypsum, U.S. Gypsum Company.

b. 100% Good Stuff Gypsum™, Art Wilson Company.

c. CAL-SUL® Pelletized Agricultural Gypsum, North Pacific Group.

d. Bumper Harvest Agricultural Gypsum, Domtar Gypsum.

e. Premium 97 Solution-Grade Gypsum, Diamond K, Inc.

f. Or equal, as approved by the Landscape Architect.

C. Soil Sulfur: Elemental Sulfur (90% min.) commercially manufactured, water degradable, palletized.

1. Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Gro-Power Iron, Gro-Power, Chino, CA.

b. Iron 45 w/ Micronutrients, Tri-C Enterprises LLC, Chino, CA.

c. Or equal, as approved by the Landscape Architect.

D. Iron: Non-staining, 40% Fe minimum, complete with micro-nutrients and 2% humic acids, as derived from iron oxide, manganese oxide, or zinc oxide.

1. Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Gro-Power Iron, Gro-Power, Chino, CA.

b. Iron 45 w/ Micronutrients, Tri-C Enterprises LLC, Chino, CA.

c. Or equal, as approved by the Landscape Architect.

E. Dolomite Lime: Agricultural-grade mineral soil conditioner containing 35% minimum magnesium carbonate, and 49% minimum calcium carbonate, 100% passing #65 sieve.

F. Potassium Sulfate (Sulfate of Potash $K_2O$), (0-0-50 guaranteed analysis N-$P_2O_5$-$K_2O$): Agricultural-grade, containing minimum 50% of water-soluble potash and 18% Sulfur (S).

G. Single Superphosphate $P_2O_5$ (0-15-0 guaranteed analysis N-$P_2O_5$-$K_2O$): Commercial product, containing 15% available phosphoric acid and 14% Sulfur.

H. Triple Superphosphate $P_2O_5$, (0-45-0 guaranteed analysis N-$P_2O_5$-$K_2O$): Commercial product, containing 45% available phosphate and 15% Calcium (Ca).

I. Ammonium Sulfate $(NH_4)_2SO_4$, (21-0-0 guaranteed analysis N-$P_2O_5$-$K_2O$): Commercial product containing approximately 21% ammonia.

J. Ammonium Nitrate NH4NO3, (34-0-0 guaranteed analysis N-P2O5-K2O): Commercial product containing approximately 34% ammonia.

K. Calcium Nitrate CaNO3, (15.5-0-0 guaranteed analysis N-P2O5-K2O): Agricultural grade containing 15-1/2% nitrogen.

L. Potassium Nitrate KNO3, (13-0-45 guaranteed analysis N-P2O5-K2O): Commercial product containing approximately 13% nitrogen and 45% potassium.

M. Ureaformaldehyde (38-0-0 guaranteed analysis N-P2O5-K2O): Granular commercial product containing approximately 38% nitrogen.

N. Urea CO(NH2)2, (46-0-0 guaranteed analysis N-P2O5-K2O): Granular commercial product containing 46% nitrogen.

O. I.B.D.U. (Iso Butyldiene Diurea): Commercial product containing 31% nitrogen.

2.05 FERTILIZER

A. Composition: Nitrogen (N), phosphorous (P2O5), and potassium (K2O) content, plus other elements, as indicated.

B. Fertilizer Tablet:

1. General: Fertilizer Tablet shall be a 7-gram tablet, organic-based, tightly compressed chip-type commercial grade, 12-month slow-release planting tablets, and shall be composed of the following available percentages by weight of plant food:

| Element/Material | Targeted Property Range |
|---|---|
| Nitrogen (N) | 12% Minimum |
| Phosphoric Acid (as P2O5) | 8% Minimum |
| Potash (as K2O) | 8% Minimum |
| Humus | 20% Minimum |
| Humic Acids w/ micronutrients and soil enhancers | 4% Minimum |

2. Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:

a. Gro-Power 12-8-8 Planting Tablets, Gro-Power.

1) Application Rate: As indicated herein Part III this Section.

b. Or equal, as approved by the Landscape Architect.

2.06 ACCESSORIES

A. Drain Rock/Aggregate: Crushed Stone, conforming to ASTM C33, graded to ¾”-size, clean, hard, durable, free of materials toxic to plant growth, set in bottom of Planters, at depth indicated in Contract Drawings. Provide Geotextile Filter Fabric between Drain Rock/Aggregate and amended planting backfill soil.

B. Wetting Agent/Water Storing Polymer: Non-biodegradable, granular, polyacrylamide polymer soil amendment.

1. Commercial-Grade Products & Manufacturers: Subject to compliance with requirements, approved through submittal.

C. Landscape Mulch Material:

1. Organic Wood Mulch: Triple Hammered Hardwood Mulch
2. Decomposed Granite: 5/8" Canyon Gold from Blessing Gravel. Tishomingo, OK.
3. Landscape Mulch Material for Submersible Planting Pots: Native River Cobble, to be approved through submittal.

## PART 3- EXECUTION

### 3.01 AGRONOMIC SOIL FERTILITY REPORT/RECOMMENDATION

A. Once rough grading has been accomplished, and prior to commencing Soil Preparation operations, (amendments, fertilizers, etc.), soil samples shall be taken from representative areas and below grade depths of the Project Site. Locations and depths to gather the representative soil samples shall be accomplished by the Contractor under the direction of the Landscape Architect.

1. Provide a minimum of ten (10) Soil Samples from locations to be coordinated.

B. Guidelines for Selecting the Soil Samples:

1. Select representative areas to sample. The area needs to be uniform in color, texture, depth, and drainage with the same fertilizing program and type of use. Planting areas to receive lawns, flowerbeds, trees, cut areas, fill areas, etc. should be tested separately. An area containing multiple trees and shrubs can be grouped into one area if the planting is the same.

2. Depths and process of soil sampling:

   a. Sample as deep as the soil will be amended, generally six-inches (6") deep for groundcover/lawns, eighteen-inches (18") deep for shrub areas, twenty-four-inches (24") deep for small boxed trees, and three-feet (3') to four-feet (4') for large boxed trees.

   b. Use a soil probe or soil auger to remove a core sample; otherwise, use a shovel to dig a hole to the desired depth. Sample the soil from the side of the excavated hole, scraping the side with a trowel. The tools used for digging shall be clean and not rusty. Avoid sampling when the soil is too wet.

3. In desired areas where multiple sub-samplings are taken from any one (1) area to create a combined sample, mix the sub-samples homogenously together in a clean plastic bucket prior to placing in the plastic bag.

4. Each Sample shall be sent directly to the laboratory in a separate, re-sealable, one (1)-gallon plastic bag. Provide a minimum of four (4) cups of soil within each respective sample to allow for adequate testing.

### 3.02 SOIL PERCOLATION TESTING

A. Type/Quantity: During operations of Agronomic Soil Fertility Testing and prior to installing Plant Material, Contractor shall perform Soil Percolation Tests, through the direction of the Landscape Architect, in selected representative areas of the Project Site, to verify acceptable natural drainage, soil structure, and soil composition. Contractor shall verify the locations of the Soil Percolation Tests with the Landscape Architect.

1. Required Number of Soil Percolation Tests: ten (10)

B. Procedure: Each Soil Percolation Test shall be performed as follows:

1. Dig a hole: 2'-0" wide x 2'-0" long x 2'-0" deep.

2. Fill the hole with water to top and cover with plywood and barricade. Allow hole to drain and fill again to top.

3. Make daily observations, noting the depth of water each day.

4. Report findings, in writing, to the Landscape Architect. Include the length of time the water takes to drain completely from each hole, date of test, location, and other information, which may be useful in providing further recommendations.

C. Results: Based on the combined results of the Agronomic Soil Fertility Testing and the Soil Percolation Tests, Contractor may be required to install additional tree drainage sumps or other drainage methods at each planting pit for trees larger than 15-gallon container stock. Contractor shall include, as a line-item price within the Base Bid, the price per each additional tree drainage sump, should they be required (based on the testing).

3.03 SOIL MOISTURE CONTENT

A. General: Do not work soil when moisture content is so great that excessive compaction occurs, or when it is so dry that dust will form in air, or that clods will not break readily. Apply water, if necessary, to bring soil to an optimum moisture content for tilling and planting. Soil moisture level prior to planting shall be no less than 75% of field capacity. The determination of adequate soil moisture for planting shall be the judgment of the Landscape Architect. Range: Maintain within two-percent (2%) above or below optimum moisture content at times during Work.

3.04 CLEARING, CULTIVATION, & EXCAVATION

A. Clearing: Clear planting areas free of stones two-inches (2") in diameter and larger, weeds, debris, and other extraneous materials prior to soil preparation Work.

B. Pre-Plant Weed Control:

1. Clear and remove existing weeds by spraying and grubbing to at least one-inch (1") below the soil surface.

2. Dead weeds shall be cleared and removed prior to planting.

3. Maintain a weed-free Project Site until final acceptance by the Owner, utilizing mechanical, chemical, or manual treatment.

C. Cultivation of Native Site, with Amendments/Fertilizers:

1. Verification: In planting areas where Native Topsoil blend will be applied, verify that sub-grades prior to installation of Topsoil have been established under rough grading. Do not spread Topsoil prior to acceptance of sub-grade Work.

2. Cultivation: Following Pre-Plant Weed Control operations, rip or cultivate verified planting areas of Native Site Soil at the indicated depth, prior to applying Imported Topsoil (if required) and Soil Amendments/Fertilizers.

a. Depth of Cultivation for existing soils: As specified in Drawings or minimum 8-inches (8”).

b. Depth of Excavation for imported soils: As specified in Drawings or minimum 8-inches (8”).

3. Following initial cultivation or excavation of existing Native Site Soil, evenly spread Imported Topsoil (if required) throughout all planting areas at the minimum indicated depth to meet finished landscape grades.

a. Depth of Imported Topsoil: As indicated on the Drawings.

b. Minimum of eight-inch (8”) at Landscape Beds or Mass Planting areas.

c. Minimum of four-inches (4”) at Sodded areas.

d. Minimum of two-inches (2”) at Permanent Seeded areas.

4. Once Imported Topsoil has been spread, uniformly broadcast all required Soil Amendments and Fertilizers as recommended through the results of the Agronomic Soil Fertility Report.

5. Thoroughly cultivate/blend all materials to provide a homogenous planting soil mixture at the indicated depth:

a. Depth of Cultivation: Minimum eight-inches (8”).

6. Lightly tamp/compact prepared Planting Soil to eliminate settlement, and complete finish grading operations.

7. Planting Soil Amendment Schedule: The Planting Soil Amendment Schedule shall be based on the combined results of the Agronomic Soil Fertility Tests and Percolation Tests and recommendations provided by the Testing Agency/Lab.

3.05 APPLICATIONS RATES

A. Fertilizer Tablets shall be spread equidistantly around the perimeter within the Amended Planting Backfill Mixture, up to within three-inches (3”) of the finished grade of the Mixture, and at the following rates:

| Size of Plant Material | Total Quantity of 7-gram tablets |
|---|---|
| One (1)-gallon Container stock. | One (1) Tablet |
| Five (5)-gallon Container stock. | Nine (6) Tablets |
| Fifteen (15)-gallon container stock | Fifteen (10) Tablets |
| 2.5” Caliper Stock | Fifteen (15) Tablets |
| 3”-4” Caliper Stock | Twenty-two (22) Tablets |
| 5”-8” Caliper Stock | Thirty-six (30) Tablets |

1. Contractor shall not provide Fertilizer Tablets for designated native plant species, if directed by the Landscape Architect. Contractor shall verify with the Landscape Architect, in writing, as to which plants are subject to not receive the Fertilizer Tablets.

B. Mycorrhizal Inoculum Application Rate:

1. During application of Fertilizer/Planting Tablets, Mycorrhizal Inoculum shall be spread equidistantly around the perimeter within the Amended Planting Backfill Mixture, up to within three (3") inches of the finished grade of the Mixture, at the prescribed application rate per the Manufacturer's written recommendations

3.06 DRAINAGE OF PLANTING AREAS

A. Surface Drainage:

1. Discrepancies: Provide proper surface drainage of planted areas. Submit in writing all discrepancies in the Contract Drawings or Specifications, or prior Work done by others, which Contractor feels precludes establishing proper drainage.

2. Correction: Include description of work required for correction or relief of said condition.

B. Detrimental Drainage, Soils and Obstructions:

1. Notification: Submit in writing all soils or drainage conditions considered detrimental to growth of plant materials. State condition and submit proposal and cost estimate for correcting condition.

2. Correction: Submit for acceptance a written proposal and cost estimate for the correction before proceeding with Work.

3. Obstructions: If rock, underground construction Work, tree roots, or other obstructions are encountered in the performance of Work under this Section, submit cost required to remove the obstructions to a depth of not less than six-inches (6") below the required soil depth.

3.07 MAINTENANCE

A. Protect graded areas from traffic and erosion. Keep free of trash and debris. Repair and reestablish grades in settled, eroded, and damaged areas.

B. Where completed areas are disturbed by construction operations or adverse weather, scarify surface, reshape, and compact to required density.

3.08 WASTE MATERIALS

A. Haul from site and legally dispose of waste materials including trash and debris as required and approved by the owner typical.

3.09 CLEAN UP

A. Upon completion of filling and grading work, remove equipment and tools. Leave site clear, clean, free of debris and ready for subsequent trades work.

END OF SECTION 319133

## SECTION 32 11 23 – AGGREGATE BASE COURSES

### PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Furnish, place and compact an aggregate base course under the proposed pavements to the depths and at the locations shown on the plans.

### 1.2 RELATED WORK

A. Specified elsewhere:

1. Section 31 23 16 – Excavation.
2. Section 31 23 23 – Fill.
3. Section 31 32 00 – Soil Stabilization.
4. Section 32 12 16 – Asphalt Paving.
5. Section 32 13 13 – Concrete Paving.

### 1.3 REGULATORY REQUIREMENTS

A. Conform to the applicable portions of Section 304 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all Supplemental Specifications and Recurring Special Provisions.

### 1.4 SUBMITTALS

A. Submit gradation and certification of material that is to be used to Engineer for review.

B. Submit name of material supplier.

C. Submit copies of Standard Proctor Density Test results to Engineer a minimum of twenty-four (24) hours prior to paving.

### 1.5 QUALITY ASSURANCE

A. Compaction Testing

1. Standard Proctor Density Testing and Compaction Testing of all aggregate base courses will be performed by the Contractor’s testing service, using Proctor information furnished by the Contractor.

2. If, in opinion of Engineer, based on testing service reports and inspection, subgrade or fills, which have been graded or placed on-site are below specified density, provide additional compaction and testing at no additional expense to the Owner.

3. When, during progress of work, tests indicate that compacted materials will not meet specifications, remove defective work, replace and retest at no additional cost to the Owner.

4. Ensure that all compacted subbases are tested before proceeding with placement of surface materials.

## PART 2 – PRODUCTS

### 2.1 MATERIALS

A. Type 5: Material used for aggregate base course shall be in accordance with the Missouri Department of Transportation (MoDOT), Standard Specification 1007. MoDOT's gradation Type 5 will be required for all impervious paved surfaces unless otherwise approved by the Engineer.

## PART 3 – EXECUTION

### 3.1 INSPECTION

A. Verify existing subgrade has been compacted and prepared and is dry and that all gradients and elevations are correct.

### 3.2 PREPARATION

A. Correct any irregularities in gradient and elevations by scarifying, reshaping and re-compacting.

B. Do not place fill on soft, muddy or frozen surfaces.

C. Prior to placement of aggregate base course, the subgrade shall be prepared in accordance with Section 209 of the MoDOT Standard Specifications and shall be proofrolled to detect areas of insufficient compaction. Proofrolling shall be accomplished by making a minimum of 2 complete passes with a fully loaded tandem-axle dump trump with a maximum weight of 20 tons, or approved equal, in each of 2 perpendicular directions. The Contractor shall document all proofroll procedure and results. Areas of failure shall be stabilized in accordance with Section 31 32 00 – Soil Stabilization.

D. Maintain moisture content of the subgrade between -2% and +3% optimum at the time of paving.

### 3.3 AGGREGATE PLACEMENT

A. Spread aggregate over the prepared subgrade to the lines and grades shown in the plans in accordance with MoDOT's Standard Specifications.

B. Compact base material to not less than 97% standard proctor.

C. Water shall be added as required by the Engineer to obtain satisfactory compaction.

### 3.4 TOLERANCES.

A. Top surface of aggregate: Plus or minus 1/4 In.

### 3.5 SURPLUS MATERIALS

A. Remove surplus materials from site.

**END OF SECTION 32 11 23**

SECTION 32 13 13- CONCRETE PAVING

PART 1- GENERAL

1.1 DESCRIPTION

A. Furnish and construct all exterior Portland cement concrete as shown on Drawings and herein specified.

1. Work to be included under this Section shall consist of the following:

a. Driveways, fire access lanes, dumpster approach, sidewalks, and any concrete pavement specified on the drawings.

B. Related Work Specified Elsewhere:

1. Section 31 20 00: Earthwork
2. Section 32 12 16: Asphalt Pavement

1.2 QUALITY ASSURANCE

A. Qualifications of Installers:

1. Provide at least 1 person at all times during execution of this portion of Work and who is thoroughly familiar with the type of materials being installed and is directly responsible for all Work performed under this Section.

B. Requirements of Regulatory Agencies:

1. It is Contractor's responsibility to comply with the requirements of the regulatory agencies, including the purchase of any permits at their own expense.

C. Construction Tolerances:

1. Vertical alignment shall not vary more than 1/8 inch from the edge of a 10-foot straight edge.

2. Horizontal alignment shall not vary more than 1/2 inch from the plan alignment for pavement.

3. Concrete thickness shall not be less than specified.

4. Reinforcing bars shall be placed to the following tolerances:

a. Clear distance to formed surface, plus or minus ¼ inch.

b. Sheared length, plus or minus 1 inch.

c. Concrete cover on top bars in slabs and beams 8 inches deep or less, 2 inches plus or minus 1/4 inch.

d. Concrete cover on top bars in members 8 inches to 24 inches deep, 2 inches plus or minus 1/2 inch.

e. Crosswise or lengthwise spacing, plus or minus 2 inches provided minimum spacing and cover requirements are not violated.

D. Reference Standards:

1. The current editions of the following American Concrete Institute (ACI) publications shall govern all Work performed hereunder, unless otherwise specified:

a. Recommended Practice for Concrete Floor and Slab Construction - ACI 302.

b. Recommended Practice for Hot Weather Concreting – ACI 305.

c. Recommended Practice for Cold Weather Concreting - ACI 306.

d. Recommended Practice for Construction of Concrete Pavements and Concrete Bases - ACI 316.

e. Building Code Requirements for Reinforced Concrete - ACI 318.

E. Design Criteria:

1. Contractor shall employ an approved independent materials testing laboratory and pay for the service of setting up the design mixes and to analyze the fine and coarse aggregate for the various uses of concrete utilized on the project. Design mixes shall be in accordance with the previously cited ACI 318 publication and in compliance with this Specification. The proposed mixes shall be submitted to OWNER for approval prior to placing of any concrete. The approved mixes established by the laboratory shall be used in the Work as long as the characteristics of the ingredients remain unchanged. If any significant change is made in the ingredients, new mixes shall be prepared and submitted to OWNER for approval.

2. Concrete shall consist of a minimum 28-day compressive design strength of 4,000 psi using Portland cement, aggregate, air entraining admixture, water and an air content ranging from 5 to 7 percent. Slump of concrete shall have a range of 2 to 4 inches.

   a. If any of the conditions vary from those as described, Contractor shall submit a revised mix design prepared by the testing laboratory along with a written request for the variance desired to OWNER for their consideration and approval.

   b. Concrete for portions of the structure required to be watertight, such as water storage, pumpstation wetwells and waste treatment tanks, shall be air-entrained and have a water-cement ratio not exceeding 0.48.

   c. Admixtures shall be used only with the approval in writing by OWNER. All admixtures shall be used in accordance with the manufacturer's instructions and shall be added at the plant. Calcium chloride shall not be used as an admixture.

   d. Mix designs shall be based on Type I cement. Type III (high early) cement or any other types of cement shall be used only when approved in writing by OWNER. When high-early cement is used, the 7-day strength test shall exceed the specified 28-day strength tests.

1.3 SUBMITTALS

A. Product Data:

1. Prepare and submit product data for OWNER'S approval. Product data shall include manufacturer's recommended installation instructions.

B. Samples:

1. If requested by OWNER, submit samples for approval of proposed materials.

C. Certification:

1. Submit 3 copies of certification material compliance as requested by OWNER.

D. Delivery Tickets:

1. Submit a delivery ticket with each truck load of concrete delivered which indicates OWNER'S design mix, truck number, project number, Contractor, ready mix producer, time of batching and total yards of concrete.

E. Test Reports and Design Mixes:

1. Submit 3 copies of design mixes and material test reports to OWNER.

PART 2- PRODUCTS

2.1 MATERIALS

A. Form Material:

1. Form material shall be either sound lumber or steel, free of defects and variations in dimensions. The sides of all lumber shall be surfaced and matched to prevent mortar leakage. Metal forms shall be of standard manufacture and need not be new but shall be free from rust and dirt. Metal forms shall be flat and true to line without punctures. All form material shall be sized and of strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal of same.

a. Rigid forms are to be utilized on tangent alignment and curves having a radius of 150 feet or greater.

b. Curved forms shall be utilized on the curved Work with a radius of 150 feet or less and shall consist of flexible spring steel or laminated lumber.

B. Reinforcement Materials:

1. Reinforcing bars and dowels shall be of new billet steel conforming to ASTM A615, Grade 60 (60,000 psi yield). Sizes of bars shall be as indicated on Drawings or herein specified.

a. Dowel bars when used for contraction and expansion joints shall be smooth steel bars coated with a thin uniform coating of liquid asphalt (MC-250) or grease on 1/2 the length of the bar plus 2 inches. In addition, dowel bars for expansion joints shall be furnished with end caps designed with one end closed, a minimum length of 3 inches and be positioned to allow bar movement of not less than 1 inch.

b. Dowel bar assemblies may be permitted if fabricated to the width of the pavement section.

c. Tie bars for control, longitudinal and construction joints shall be deformed bars.

C. Concrete Materials:

1. Portland cement shall conform to ASTM C150.

a. Cement shall be a low alkali cement (Type I) containing not more than 0.6 percent by weight of tri-sodium silicate oxide.

2. Coarse aggregate shall conform to Size 57 grade requirements of Table 2 of ASTM C33 standard.

3. Fine aggregate shall conform to ASTM C33 with fineness modulus not to vary more than 0.20 from value assumed in design mix.

4. Water shall be potable, clean and free from deleterious amounts of acid, alkali or organic material.

D. Admixtures:

1. Air entraining agent shall conform to ASTM C260 and shall be added at the mixer.

2. Water reducing agents, (such as super plasticizers), retarding agents, accelerating agents and all other admixtures, shall require approval by OWNER and if used, shall conform to ASTM C494. In no case shall admixtures be permitted as substitute for cement content specified, unless approved by OWNER.

E. Expansion Joint Material:

1. Joint filler material shall consist of a non-extruding standard bituminous bound type "Sealtight Asphalt Expansion Joint" as manufactured by W.R. Meadows, Inc., Elgin, Illinois or OWNER approved equal.

    a. Material shall conform to ASTM D994.

2. Joint filler material shall consist of preformed non-extruded bituminous bound type "Sealtight-Fibre Expansion Joint" as manufactured by W.R. Meadows, Inc., Elgin, Illinois; "Code 1390" as manufactured by W.R. Grace Company, Cambridge, Massachusetts or OWNER approved equal.

    a. Material shall conform to ASTM D1751.

    b. Material shall be 1/2 inch thick, unless otherwise noted, of widths equal to slab thickness less 1/2 inch or as otherwise indicated.

3. Joint sealant shall be a single component, polyurethane type "Sikaflex-la" as manufactured by Sika Chemical Corporation, Lyndhurst, New Jersey or OWNER approved equal. Color as selected by OWNER.

F. Curing Materials:

1. Kraft paper shall be waterproof and nonstaining "Sisalkraft 5K-10" conforming to ASTM C171.

2. Polyethylene film shall be white opaque sheet or roll material not less than 0.006 inch thick (6 mil) conforming to AASHTO-M171.

3. Contractor may at their option use a liquid curing compound for surfaces that will not receive treating oil or waterproofing membrane. Liquid curing compound shall conform to ASTM C309 and shall consist of the following:

    a. Type 1D, translucent with fugitive dye.

    b. Type 2, white pigmented, Class B (vehicle solids restricted to all resin).

2.2 PRODUCTION

A. Concrete shall be ready-mixed, and shall be batched, mixed and transported in accordance with "Specification for Ready-Mixed Concrete" ASTM C94. The production plant equipment and facilities shall meet the requirements of the National Ready Mixed Concrete Association.

PART 3- EXECUTION

3.1 JOB CONDITIONS

A. Hot Weather Conditions:

1. The following precautions shall be adhered to:

    a. Reject concrete mixture having temperature of 85ºF or greater.

    b. Pre wet subgrade.

    c. Crushed or flaked ice may be utilized in reducing temperature of mixture.

    d. If necessary, reduce temperature of reinforcing steel with wet burlap.

e. Reduce mixing time (agitating time) in truck to 45 minutes.

f. During periods of high winds, shelter windward side with adequate wind breaks.

g. Apply no chemical retarder to finished surface unless permission is granted in writing by OWNER.

B. Cold Weather Conditions:

1. When ambient temperature is 40ºF or less, the following precautions are to be adhered to:

a. Subbase shall not be frozen.

b. Concrete mixture delivered at Worksite shall be 55ºF (minimum), 85ºF (maximum).

c. No calcium chlorides, salts or other chemical accelerators shall be permitted, unless otherwise acceptable in writing by OWNER.

d. Concrete surface shall be maintained at a minimum of 50ºF with appropriate thermal insulation for a period of 7 days (normal concrete), 3 days (high early-strength concrete).

e. Refer to previously cited ACI 306 for minimum thickness of thermal protection required.

f. Any concrete that has frozen or disintegrated as a result of freezing shall be removed and replaced at Contractor's expense.

3.2 SUBGRADE PREPARATION

A. Fine grade and compact subgrade to the plan cross section. Compaction shall be as specified in Section 312000 of this Specification or as indicated on the Drawings.

B. After compaction, cut-out soft spots and unstable areas in the subgrade and fill with select fill material and compact as specified in Section 312000.

3.3 GRANULAR BASE

A. Construct the select fill and granular base as shown on Drawings on the prepared subgrade after the final shaping and compacting of the subgrade is completed.

B. Compact as specified base in Section 312000 of this Specification.

3.4 FORM CONSTRUCTION

A. Forms shall have the strength and rigidity, regardless of material, such that when they are set in place and braced, they will withstand weight of equipment and weight of concrete without settlement or lateral displacement.

B. Keyway forms in the edge of pavement slabs and at construction joints shall be constructed to the dimensions shown on Drawings. Wood keyway forms, if used, shall be bolted or nailed to the side forms. Metal keyway forms shall be fixed or held rigidly in place by staking or other OWNER approved method.

C. Forms shall be coated prior to the placement of concrete, with a nonstaining form release agent. Wooden form may be prewetted with water. No standing water, adjacent to forms, shall be permitted.

3.5 REMOVAL OF FORMS

A. Forms for slabs on grade shall not be removed earlier than 12 hours after the placement of concrete has been completed. Within 24 hours of form removal backfill adjacent to the pavement shall be completed.

B. Forms supporting the weight of concrete shall not be released until the concrete has reached its specified 28-day strength. Minimum time elapse after casting and before the false Work supports are released shall be 8 days for spans up to 96 inches center to center of supports, plus 1 additional day for each 12 inches of increase in span length over 84 inches up to 14 days for span of 14 feet and over. Such time period shall be exclusive of those time intervals during which the concrete surface temperature is below 40ºF. If temperature remains below 40ºF during the casting and curing period no forms shall be removed until approved field tests indicating adequate concrete strength have been provided.

3.6 REINFORCEMENT REPLACEMENT

A. Tie bars, reinforcement bars and dowel bars shall be clean, free from rust and shall be placed on adequate supports in locations as shown on Drawings. Provide the following minimum thickness of concrete cover:

1. Concrete deposited on ground: 3 inches.
2. Formed surfaces against ground: 1-1/2 inches.
3. Beams, girders and columns: 1-1/2 inches.
4. Slabs, walls and joists: 1 inch.
5. Clear distance between parallel bars: 1 inch or nominal bar distance.
6. For No. 6 bars or larger: 2 inches.
7. No broken brick, block or concrete shall be permitted as reinforcement supports.

B. Welded steel wire fabric shall be placed free from rust, kinks and bends and shall be cut in such a way that the overlap measured between outer mark cross wires of each fabric sheet is not less than 2 inches. The fabric shall be cut at contraction joints. It shall be supported by a layer of fresh concrete placed to the depth of the mesh shown on Drawings, followed by placement of the upper layer of concrete.

3.7 CONCRETE PLACEMENT

A. Place concrete to required depth and width to form a continuous mass requiring a minimum of rehandling. Concrete adjacent to side forms and fixed structures shall be consolidated by means of portable vibrators or by mechanical means with the use of hand spading. Vibrators shall not be used to move concrete horizontally.

B. If it is necessary to place a construction joint prior to a contraction joint, the distance between the construction joint and the previous contraction joint shall not be less than 60 inches.

C. Automatic machine may be used for curb and gutter placement at Contractor's option, if acceptable to OWNER. If machine placement is to be used, submit revised mix design and laboratory test results, which meet or exceed the minimum herein specified. Machine placement must produce curbs and gutters to the required cross-section, lines, grades, finish, and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete as specified.

3.8 JOINTS

A. General:

1. Construct expansion, contraction and construction joints with face perpendicular to surface of concrete.

2. Where joining existing structures, match existing contraction or expansion joints.

B. Expansion Joints:

1. All fixed objects, such as buildings and structures or pavement, sidewalks or curb intersections shall be separated by a 1/2 inch expansion joint placed at the full depth of the concrete thickness. Expansion joints, in addition to the above, shall be placed at 60 foot intervals in the following:

   a. Concrete curb and gutter

   b. Concrete walk

2. For pavement construction, place expansion joints as shown on Drawings.

C. Contraction Joints:

1. Contraction joints shall be placed at the following intervals and dimensions or as shown on Drawings:

   a. Concrete curb and gutter – 10 feet; 1/8 inch wide by 1 1/2 inch depth.

   b. Concrete wal – 10 feet; 1/8 inch wide by 1/4 the depth of concrete.

2. Cut plastic concrete with appropriate tool to specified depth. Finish edges with 1/4 inch radius tool.

3. Saw-cut joints to specified width and depth on hardened concrete as soon as concrete has hardened sufficiently to prevent raveling or damage to the joint.

D. Joint Sealer:

1. Apply joint sealer to a clean and dry expansion or contraction joint if specified to a point approximately 1/4 inch below the top surface. Where oil treatment is specified, joint sealer shall be applied prior to application of the oil.

3.9 CONCRETE FINISH

A. After initial strike-off and floating, and prior to finishing, test surface with 10-foot straightedge. Correct irregularities prior to final finishing operations.

B. Apply the following surface finish after surface sheen or excess moisture has disappeared:

1. Apply steel trowel finish followed by stiff-bristled broom drawn across concrete surfaces, perpendicular to line of traffic:

   a. Sidewalk

   b. Concrete pavement

   c. Curb and gutter

3.10 CONCRETE CURING AND PRTOECTION

A. Cure concrete surfaces for 7 days (normal concrete) and for 3 days (high early-strength concrete), using appropriate means of protection as previously cited in ACI 305 and ACI 306.

B. Curing methods shall consist of one of the following:

1. Keep concrete surface continuously wet by ponding with water.

2. Apply moisture proof fabric to entire area lapping joints and edges at least 3 inches. Tape interior joints and weight edges down with sand or other approved material.

3. Apply liquid membrane curing compound to the finished surface in a 2 coat continuous operation with second application applied transversely to the direction of the first application, and in accordance with the manufacturer's directions. Replace damaged areas with equal applications of membrane using compound. Liquid membrane curing compound shall not be permitted where the surface will be subjected to an application of waterproof coatings, bonding agents, treating oil or paint.

3.11 TESTING EVALUATION

A. Concrete materials and operations shall be tested and inspected as the Work progresses, by an independent testing laboratory. Contractor shall furnish any necessary labor who is familiar with methods of sampling and shall assist the testing agency in obtaining and handling samples, and for safe storage and proper curing of concrete test specimens on Worksite.

B. Mold and cure three standard 6-inch diameter specimens from each sample in accordance with ASTM C31. Compressive strength test specimens shall be in accordance with ASTM C39. Two specimens shall be tested at 28 days for acceptance and one shall be tested at 7 days for information. The acceptance test results shall be the average of the strengths of the two specimens tested at 28 days. If one specimen in a test manifests evidence of improper sampling, molding or testing, it shall be discarded and the strength of the remaining cylinder shall be considered the test result. Should both specimens in a test show any of the above defects, the entire test shall be discarded. When high-early strength concrete is used, the first specimen shall be tested at 3 days; the remaining two at 7 days.

C. Make at least one strength test for each 50 cubic yards, or fraction thereof, of each mix design of concrete placed in any one day.

D. Determine slump of the concrete sample for each strength test and whenever consistency of concrete appears to vary, using standard slump cone as per ASTM C143.

E. The testing laboratory shall report all test and inspection results to OWNER, OWNER’S Engineer, and Contractor immediately after they are performed. All concrete test reports shall include name of job, date of placement, date of test, batch mix design, slump and the exact location in the Work at which the batch represented by the test was deposited.

F. All costs necessary to prepare concrete test cylinders, make tests and furnishing of written reports shall be borne by the Contractor.

3.12 DEFECTIVE WORK

A. When tests and inspections of the aggregate base and/or concrete Work indicate non-compliance with the Specification, Contractor and OWNER shall mutually agree on the number and location of additional tests to define and/or verify the deficiency. If the average of the tests for a given area indicate non-compliance the area is considered defective and Contractor shall:

1. Remove and replace defective Work at no cost to OWNER;

2. Correct the Work at no cost to OWNER in a manner acceptable to OWNER;

3. Give OWNER a credit towards the Contract Price if it is acceptable to OWNER;

4. If Work is found to be in noncompliance, Contractor shall pay for the defective area removal and replacement, and the tests and inspection costs; or

5. If Work is found to be in compliance, OWNER shall pay for tests and inspection costs.

END OF SECTION 32 13 13

SECTION 32 13 73- CONCRETE PAVING JOINT SEALANTS

PART 1- GENERAL

1.1 SCOPE OF WORK

A. Section Includes:

1. Cold-applied sealant joints.
2. Hot-applied joint sealants.
3. Joint-sealant backer materials.
4. Primers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each kind and color of joint sealant required.

C. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

PART 2- PRODUCTS

2.1 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.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type NS.

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.

C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.

D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.

E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.

2.3 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I.

B. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I or Type II.

C. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I, II, or III.

D. D 6690, Type IV.

2.4 JOINT-SEALANT BACKER MATERIALS

A. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

C. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3- EXECUTION

3.1 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Cleaning of Joints: Clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

C. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer.

D. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

E. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

F. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

G. Tooling of Non-sag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

H. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

I. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

END OF SECTION 32 13 73

## SECTION 32 14 13 CONCRETE PAVER MATERIALS

### PART 1 GENERAL

1.01 SUMMARY

A. Section includes the following:
1. Concrete Pavers
2. Joint Sand
3. Setting Bed Sand
4. Base Aggregate
5. Subbase Aggregate

1.02 REFERENCES

A. ASTM International, latest edition:

1. C 33, Standard Specification for Concrete Aggregates.
2. C 136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
3. C 140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
4. C 144 Standard Specifications for Aggregate for Masonry Mortar.
5. C 936, Standard Specification for Solid Concrete Interlocking Paving Units.
6. C 979, Standard Specification for Pigments for Integrally Colored Concrete.
7. C 1645 Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units
8. D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
9. D 4533, Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles
10. D 4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
11. D 4491, Standard Test Method for Water Permeability of Geotextiles by Permittivity
12. D 4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile

B. Illinois Department of Transportation:

1. Standard Specifications for Road and Bridge Construction, January 2010, including all addenda.

1.03 SUBMITTALS

A. Concrete Pavers:

1. Samples for verification: Three representative full-size samples of each paver type, thickness, color and finish that indicate the range of color variation and texture expected upon project completion.
2. Accepted samples become the standard of acceptance for the product produced.
3. Test results from an independent testing laboratory for compliance of concrete pavers with ASTM C 936.
4. Manufacturer’s catalog product data, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

B. Joint and Setting Bed Sand:

1. Provide three representative one pound samples in containers of Joint Sand materials.
2. Provide three representative one pound samples in containers of Setting Bed Sand materials.
3. Test results from an independent testing laboratory for sieve analysis per ASTM C 136 conforming to the grading requirements of ASTM C 144.

C. Polymeric Joint Sand:
1. Test results from an independent testing laboratory for sieve analysis per ASTM C 136 conforming to the grading requirements of ASTM C 144.
2. Samples for Initial Selection: Provide three representative samples in containers of Setting Bed Sand material, cured and dried, for color selection.
3. Samples for Verification: Provide three one pound samples in containers of Polymeric Joint Sand.

D. Base and Subbase Aggregate:

1. Test results from an independent testing laboratory for sieve analysis per ASTM C 136.

E. Paving Installation Contractor:

1. Job references from a minimum of three projects similar in size and complexity. Provide Owner/Client/General Contractor names, postal address, phone, fax, and email address.

1.04 QUALITY ASSURANCE

A. Utilize a Manufacturer having at least ten years of experience manufacturing concrete pavers on projects of similar nature or project size.

B: Source Limitations:

1. Obtain Concrete Pavers from one source location with the resources to provide products of consistent quality in appearance and physical properties.
2. Obtain Joint and Setting Bed Sands from one source with the resources to provide materials and products of consistent quality in appearance and physical properties.
3. Obtain Polymeric Joint Sand from one source with the resources to provide materials and products of consistent quality in appearance and physical properties.

C. Paving Contractor Qualifications:

1. Utilize an installer having successfully completed concrete paver installation similar in design, material, and extent indicated on this project.

D. Mockups:

1. Install a 5 ft x 5 ft paver area per each paving pattern.
2. Use this area to determine surcharge of the Setting Bed Sand layer, joint sizes, lines, laying pattern(s) and levelness. This area will serve as the standard by which the workmanship will be judged.
3. Subject to acceptance by owner, mock-up may be retained as part of finished work.
4. If mock-up is not retained, remove and dispose legally.

1.05 DELIVERY, STORAGE & HANDLING

A. In accordance with Conditions of the Contract and Division 1 Product Requirement Section.

B. Deliver Concrete Pavers in manufacturer’s original, unopened and undamaged container packaging with identification labels intact.

1. Coordinate delivery and paving schedule to minimize interference with normal use of streets and sidewalks adjacent to paver installation.
2. Deliver Concrete Pavers to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by forklift or clamp lift.

3. Unload Concrete Pavers at job site in such a manner that no damage occurs to the product or adjacent surfaces.

C. Store and protect materials free from mud, dirt and other foreign materials.

D. Prevent Joint and Setting Bed Sand from exposure to rainfall or removal by wind with secure, waterproof covering.

E. Store Polymeric Joint Sand on elevated platforms, under a cover and/or in a dry location.

1.06 PROJECT/SITE CONDITIONS

A. Environmental Requirements:

1. Install Concrete Pavers only on unfrozen and dry Setting Bed Sand.
2. Install Concrete Pavers only on unfrozen and dry Base or Subbase Aggregate materials.
3. Install Base or Subbase Aggregates only over unfrozen subgrade.
4. Install Setting Bed Sand or Concrete Pavers only when there is no heavy rain or snowfall.

B. Weather Limitations for Polymeric Jointing Sand:

1. Install Polymeric Joint Sand only when ambient temperature is above 40°F (5°C), under dry conditions with no rain forecast for 24 hours and when surface of pavement is completely dry.

1.07 CONCRETE PAVER OVERAGE AND ATTIC STOCK

A. Provide a minimum of 5% additional material for overage to be used during construction.

B. Contractor to provide 100 square feet of each product and size used to owner for maintenance and repair. Furnish Pavers from the same production run as installed materials.

C. Manufacture to supply maintenance and reinstatement manuals for Concrete Paver units.

**PART 2 PRODUCTS**

2.01 CONCRETE PAVERS

A. Basis-of-Design Product: The Concrete Paver shapes are based on:

1. Unilock:

a. Eco Promenade (MSU Standard)

2. As manufactured by:
Unilock
Uxbridge MA, Brewster NY, Rittman OH, Brighton MI, Aurora IL, Marengo IL, Elkhorn WI, Ayr ON, Georgetown ON, Pickering ON, Gormley ON
Contact: Chicago- Brad Swanson – brad.swanson@unilock.com 630-742-4168
New York - Mike Zengen – mike.zengen@unilock.com 845-538-7914
Ontario – Dave Laurie – dave.laurie@unilock.com 416-805-6399

3. The specified products establish minimum requirements that substitutions must meet to be considered acceptable.

   a. To obtain acceptance of unspecified products, submit written requests at least 7 days before the Bid Date.

Enclosed pavers via UniLock representative Jake Kline:

- (1 EA) 3x12 UniLock Promenade Steel Gray (non-permeable)
- (1 EA) 3x12 UniLock EcoPromenade (permeable)

B. Product requirements:

1. Concrete Paver Type 1: Unilock Eco Promenade (Permeable)

   a. Finish: Standard
   b. Color: Steel Gray
   c. Edge: Concrete or Steel
   d. Size: Manufacture the sizes indicated with a maximum tolerance of plus or minus 1/16 inch for length and width. Maximum height tolerance of plus or minus 1/8 inch.

      1) 3x12”
      Note: Imperial dimensions are nominal equivalents to the metric dimensions.

   d.

C. Provide pavers meeting the minimum material and physical properties set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units. Efflorescence is not a cause for rejection.

1. Average compressive strength 8000 psi (55MPa) with no individual unit under 7,200 psi (50 MPa).
2. Average absorption of 5% with no unit greater than 7% when tested according to ASTM C 140.
3. Conforming to ASTM C 1645 when tested for freeze-thaw requirements.
4. Height tolerances +/- 3.2 mm (1/8 in).
Note: Efflorescence is a whitish powder-like deposit that sometimes appears on concrete products. Calcium hydroxide and other water-soluble materials form or are present during the hydration of Portland cement. Pore water becomes saturated with these materials, and diffuses to the surface of the concrete. When this water evaporates, the soluble materials remain as a whitish deposit on the concrete surface. The calcium hydroxide is converted to calcium carbonate during a reaction with carbon dioxide from the atmosphere. The calcium carbonate is difficult to remove with water. However, the efflorescence will wear off with time, and it is advisable to wait a few months before attempting to remove any efflorescence. Commercially available cleaners can be used, provided directions are carefully followed. Some cleaners contain acids that may alter the color of the pavers.

D. Accept only pigments in concrete pavers conforming to ASTM C 979.

E. Maximum allowable breakage of product is 5%.

2.02 JOINT SAND

A. Provide natural Joint Sand as follows:

1. Washed, clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
2. Do not use limestone screenings, stone dust, or sand for the Joint Sand material that does not conform to conform to the grading requirements of ASTM C 33.
4. Utilize sands that are as hard as practically available where concrete pavers are subject to vehicular traffic.

5. Gradation as shown in Table 1 below:

**TABLE 1 – JOINT SAND**
**GRADATION REQUIREMENTS FOR JOINT SAND**

| **ASTM C 144** | | |
|---|---|---|
| **Sieve Size** | **Natural Sand Percent Passing** | **Manufactured Sand Percent Passing** |
| No. 4 (4.75 mm) | 100 | 100 |
| No. 8 (2.36 mm) | 95 to 100 | 95 to 100 |
| No. 16 (1.18 mm) | 70 to 100 | 70 to 100 |
| No. 30 (0.600 mm) | 40 to 75 | 40 to 75 |
| No. 50 (0.300 mm) | 10 to 30 | 20 to 40 |
| No. 100 (0.150 mm) | 2 to 15 | 10 to 25 |
| No. 200 (0.075) | 0 to 1 | 0 to 10 |

2.03 POLYMERIC JOINT SAND

A. Provide Polymeric Joint Sand as manufactured by:

1. Alliance Gator G2

a. Product Type: Dry mix, contains polymeric binding agent, activated with water.
b. Color: (Insert color Beige, Slate Grey, Ivory or Black Diamond)

2. Unicare HP Polymeric Max Sand

a. Product Type: Dry mix, contains polymeric binding agent, activated with water.
b. Color: (Insert color Grey, Tan or custom)

3. Polybind G2 Complete (Nevada Tan, Oxford Grey, Jet Black, Ivory White)

B. Provide Polymeric Joint Sand meeting the minimum material and physical properties as follows:

1. Compression Strength: proven resistance to compression of 300 PSI minimum after drying for 7 days under controlled conditions (73°F (23°C) at 50% humidity).

a. Test sand sample shape: cylinder (2” (5 cm) dia. X 4” (10 cm) high).
b. Gradation as shown Table 1 above.

2.04 SETTING BED SAND

A. Provide Setting Bed Sand as follows:

1. Washed, clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.
2. Do not use limestone screenings, stone dust, or sand material that does not conform to conform to the grading requirements of ASTM C 33.
3. Do not use mason sand or sand conforming to ASTM C 144.
4. Utilize sands that are as hard as practically available where concrete pavers are subject to vehicular traffic.
5. Conform to the grading requirements of ASTM C 33 with modifications as shown in Table 2 below:

**TABLE 2 – SETTING BED SAND**
**GRADATION REQUIREMENTS FOR SETTING BED SAND**

| **ASTM C 33** | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| 3/8 in (9.5 mm) | 100 |
| No. 4 (4.75 mm) | 95 to 100 |
| No. 8 (2.36 mm) | 85 to 100 |
| No. 16 (1.18 mm) | 50 to 85 |
| No. 30 (0.600 mm) | 25 to 60 |
| No. 50 (0.300 mm) | 10 to 30 |
| No. 100 (0.150 mm) | 2 to 10 |
| No. 200 (0.075) | 0 to 1 |

Note: Coarser sand than that specified in Table 1 above may be used for joint sand including C 33 material as shown in Table 2. Use material where the largest sieve size easily enters the smallest joints. For example, if the smallest paver joints are 2 mm wide, use sand 2 mm and smaller in particle size. If C 33 sand is used for joint sand, extra effort may be required in sweeping material and compacting the pavers in order to completely fill the joints.

2.05 GEOTEXTILE

A. Provide Geotextile material conforming to the following performance characteristics, measured per the test methods referenced:

1. 4 oz., nonwoven needle punched geotextile composed of 100% polypropylene staple fibers that are inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.
2. Grab Tensile Strength: ASTM D 4632: 115 lbs.
3. Grab Tensile Elongation: ASTM D 4632: 50%
4. Trapezoidal Tear: ASTM D 4533: 50 lbs.
5. Puncture: ASTM D 4833: 65 lbs.
6. Apparent Opening Size: ASTM D 4751: 0.212 mm, 70 U.S. Sieve
7. Permittivity: ASTM D 4491: 2.0 sec -1
8. Flow Rate: ASTM D 4491: 140 gal/min/s.f.

B. As supplied by Unilock
Contact: Unilock
Uxbridge MA, Brewster NY, Rittman OH, Brighton MI, Aurora IL, Marengo IL, Elkhorn WI, Ayr ON, Georgetown ON, Pickering ON, Gormley ON
Contact: Chicago- Brad Swanson – brad.swanson@unilock.com 630-742-4168
New York - Mike Zengen – mike.zengen@unilock.com 845-538-7914
Ontario – Dave Laurie – dave.laurie@unilock.com 416-805-6399

1. Carthage Mills – FX-40HS
2. U.S. Fabrics
3. Mirafi
4. Gator Fabric

2.06 EDGE RESTRAINTS

A. Concrete Edge Restraint as indicated.

B. Plastic and Metal Edge Restraints:

1. Permaloc, www.permaloc.com

a. Material Type: Aluminum
b. Model No.: 3 inch GeoEdge capture plate and geogrid

2. SEK Surebond

a. Model No.: 8 feet PermEdge with attached geogrid

3. Snap Edge

a. Material Type: Plastic
b. Model No.: One Piece Edging, 96 inches

4. Pave Tech

a. Material Type: Plastic
b. Model No.: Pave Edge Rigid, Pave Edge Flexible, Pave Edge Industrial

5. Polybind Edge

a. Material Type: Plastic
b. Rigid 33
c. Flex 34

6. Alliance Gator Edge

a. Material Type: Plastic
b. Rigid
c. Flex

## PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas indicated to receive paving for compliance with requirements for installation tolerances and other conditions affecting performance for the following before placing the Concrete Pavers.

1. Verify that Geotextiles, if applicable, have been placed according to drawings and specifications.
2. Verify the Concrete Underlayment has cured.
3. Verify the Concrete Underlayment thickness, strengths, surface tolerances and elevations conform to specified requirements.
4. Provide written density test results for soil subgrade, Concrete Underlayment P.S.I testing to the Owner, General Contractor and paver installation subcontractor.
5. Verify location, type, and elevations of edge restraints, concrete curbing, concrete collars around utility structures, and drainage inlets.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Beginning of Bedding Sand and Concrete Paver installation signifies acceptance of Base and edge restraints.

3.02 PREPARATION

A. Verify the Concrete Underlayment is clean and dry, certified by General Contractor as meeting material, installation and grade specifications.

B. Stockpile Setting Bed Sand and Joint Sand such that they are free from standing water, uniformly graded, free of any organic material or sediment, debris, and ready for placement.

C. Verify that base and Geotextile is ready to support sand, edge restraints, and, pavers and imposed loads.

D. Keep area where pavement is to be constructed free from sediment during entire job. Remove and replace all Geotextile, Joint Sand and Setting Bed Sand materials contaminated with sediment with clean materials.

E. Edge Restraint Preparation: (if not using a concrete edge restraint)

1. Install edge restraints per the drawings.
2. Mount directly to finished base. Do not install on bedding sand.
3. Extend the minimum distance from the outside edge of the Concrete Underlayment to the spikes equal to the thickness of the slab.

3.03 INSTALLATION

A. SETTING BED SAND

1. Provide, spread and screed Setting Bed Sand evenly over the Concrete Underlayment.

    a. Protect screeded Setting Bed Sand from being disturbed by either pedestrian or vehicular traffic.
    b. Screed only the area which can be covered by pavers in one day.

2. Keep moisture content constant and density loose and constant until Concrete Pavers are set and compacted.
3. Screed Setting Bed Sand using either an approved mechanical spreader (e.g.: an asphalt paver) or by the use of screed rails and boards. Maintain in a loose condition slightly ahead of the paving units and fully protect against incidental compaction following screeding. Loosen compacted sand by rain or screeded sand left overnight before further paving units are placed.
4. Inspect the Setting Bed Sand course prior to commencing the placement of the Concrete Pavers. Acceptance of the Setting Bed Sand occurs with the initiation of Concrete Paver placement.

B. CONCRETE PAVERS

1. Replace Concrete Pavers with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.
2. Mix Concrete Pavers from a minimum of three (3) bundles simultaneously drawing the paver vertically rather than horizontally, as they are placed, to produce uniform blend of colors and textures. (Color variation occurs with all concrete products. This phenomenon is influenced by a variety of factors, e.g. moisture content, curing conditions, different aggregates and, most commonly, from different production runs. By installing from a minimum of three (3) bundles simultaneously, variation in color is dispersed and blended throughout the project).
3. Exercise care in handling face mix concrete pavers to prevent surfaces from contacting backs or edges of other units.
4. Provide Concrete Pavers using laying pattern as indicated. Adjust laying pattern at pavement edges such that cutting of edge pavers is minimized. Cut all pavers exposed to vehicular tires no smaller than one-third of a whole paver.
5. Use string lines or chalk lines on Setting Bed Sand to hold all pattern lines true.
6. Set surface elevation of pavers 1/8 in. (3 mm) above adjacent drainage inlets, concrete collars or channels.

7. Place units hand tight against spacer bars. Adjust horizontal placement of laid pavers to align straight.

    a. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.

8. Provide space between paver units of 1/32 in. (1 mm) wide to achieve straight bond lines.
9. Prevent joint (bond) lines from shifting more than ±1/2 in. (±13 mm) over 50 ft. (15 m) from string lines.
10. Fill gaps between units or at edges of the paved area that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.
11. Prevent all traffic on installed Concrete Pavers until Joint Sand has been vibrated into joints. Keep skid steer and forklift equipment off newly laid Concrete Pavers that have not received initial compaction and Joint Sand material.
12. Vibrate Concrete Pavers into leveling course with a low-amplitude plate vibrator capable of a to 5000-lbf (22-kN) compaction force at 80 to 90 Hz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:

    a. After edge pavers are installed and there is a completed surface or before surface is exposed to rain.
    b. Compact installed Concrete Pavers to within 6 feet (2 meters) of the laying face before ending each day's work. Cover Concrete Pavers that have not been compacted and leveling course on which pavers have not been placed, with nonstaining plastic sheets to prevent Setting Bed Sand from becoming disturbed.

13. Protect face mix Concrete Paver surface from scuffing during compaction by utilizing a urethane pad.
14. Remove any cracked or structurally damaged Concrete Pavers and replace with new units prior to installing Joint Sand material.

C. JOINT SAND

1. Provide, spread and sweep dry Joint Sand into joints immediately after vibrating pavers into Setting Bed Sand course until full. Vibrate pavers and add Joint Sand material until joints are completely filled, then remove excess material. This will require at least 4 passes with a plate compactor.
2. Leave all work to within 3 ft. (1 m) of the laying face fully compacted with sandfilled joints at the completion of each day.
3. Remove excess Joint Sand broom clean from surface when installation is complete.
4. Polymeric Joint Sand

    a. Install Polymeric Joint Sand per manufacturers recommended instructions.
    Retain subparagraph above or below and detail on Drawings if pavers set in mortar or embedded in concrete are used as edge restraints for aggregate-set pavers.

3.04 FIELD QUALITY CONTROL

A. Verify final elevations for conformance to the drawings after sweeping the surface clean.

1. Prevent final Concrete Paver finished grade elevations from deviating more than ±3/8 in. (±10 mm) under a 10 ft (3 m) straightedge or indicated slope, for finished surface of paving.

B. Lippage: Paver-to-Paver Lippage:

1. No greater than 3 mm (1/8 inch) difference in height between adjacent pavers.
*Note: The industry standard acceptable lippage between adjacent pavers is 3 mm (1/8 inch). Achieving a completely flush paver surface is most desirable but may be unattainable depending on factors such as paver type, setting bed materials or depth, ASTM manufacturing standards or other specific project needs. Consult with your Unilock representative to determine the best approach for a reasonable lippage tolerance on each project.*

3.05 REPAIRING, CLEANING AND SEALING

A. Remove and replace unit 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.

B. Cleaning: Remove excess dirt, debris, stains, grit, etc. from exposed paver surfaces; wash and scrub clean.

1. Clean Concrete Pavers in accordance with the manufacturer's written recommendations.

3.06 PROTECTION

A. Protect completed work from damage due to subsequent construction activity on the site.

END OF SECTION 32 14 13

## SECTION 32 14 13.19- PERMEABLE CONCRETE PAVER MATERIALS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section includes the following:

1. Permeable Concrete Pavers
2. Permeable Joint Opening Aggregate
3. Permeable Joint Aggregate Type 1
4. Permeable Joint Aggregate Type 2
5. Permeable Setting Bed Aggregate (Open-graded)
6. Permeable Base Aggregate (Open-graded)
7. Permeable Subbase Aggregate (Open-graded)

### 1.02 REFERENCES

Note: Design street, industrial, port and airport pavement thicknesses in consultation with a qualified civil engineer, in accordance with established flexible pavement design procedures, LOCKPAVE® software, and in accordance with Interlocking Concrete Pavement Institute Technical Bulletins. Sample construction detail drawings are available from Unilock®. This specification may require modifications.

A. ASTM International, latest edition:

1. C 29 Bulk Density and Voids in Aggregate Materials.
2. C 33, Standard Specification for Concrete Aggregates.
3. C 136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
4. C 140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
5. D 448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
6. C 936, Standard Specification for Solid Concrete Interlocking Paving Units.
7. C 979, Standard Specification for Pigments for Integrally Colored Concrete.
8. D 698 Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 5.5 lb (24.4 N) Rammer and 12 in. (305 mm) drop.
9. D 1557 Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 10lb (44.5 N) Rammer and 18 in. (457 mm) drop.
10. C1645 Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units
11. D 4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
12. D 4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
13. D 4533, Standard Test Method for Index Trapezoidal Tearing Strength of Geotextiles
14. D 4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
15. D 4491, Standard Test Method for Water Permeability of Geotextiles by Permittivity
16. D 4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile
    Note: In order to determine the latest version of the listed specifications and standards, please consult the ASTM web page (www.astm.com)

B. U.S. Green Building Council Leadership in Energy and Environmental Design (LEED)

1. Building Design + Construction, latest edition

### 1.03 SUBMITTALS

A. Permeable Concrete Pavers:

1. Samples for verification: Three representative full-size samples of each paver type, thickness, color and finish that indicate the range of color variation and texture expected upon project completion.

2. Accepted samples become the standard of acceptance for the product produced.
3. Test results from an independent testing laboratory for compliance of concrete pavers with ASTM C 936.
4. Manufacturer's catalog product data, installation instructions, and material safety data sheets for the safe handling of the specified materials and products.

B. Permeable Joint Opening Aggregate:

1. Provide three representative, one pound samples in containers of aggregate materials that indicate the range of color variation and texture expected upon project completion.
2. Accepted samples become the standard of acceptance for the product produced.
3. Test results from an independent testing laboratory for sieve analysis, including washed gradations per ASTM C 136.
4. Test results for void space percentage per ASTM C 29.

C. Permeable Setting Bed, Base and Subbase Aggregate:

1. Test results from an independent testing laboratory for compliance with ASTM D 448 No. 8, No. 57 and No. 2.
2. Test results from an independent testing laboratory for sieve analysis, including washed gradations per ASTM C 136.
3. Test results for void space percentage per ASTM C 29.

D. Paving Installation Contractor:

1. Job references from a minimum of three projects similar in size and complexity. Provide Owner/Client/General Contractor names, postal address, phone, fax, and email address.

1.04 QUALITY ASSURANCE

A. Utilize a Manufacturer having at least ten years of experience manufacturing interlocking concrete pavers on projects of similar nature or project size.

B: Source Limitations:

1. Obtain Permeable Concrete Pavers from one source location with the resources to provide products of consistent quality in appearance and physical properties.
2. Obtain Permeable Joint Opening Aggregate from one source with the resources to provide materials and products of consistent quality in appearance and physical properties.

C. Paving Contractor Qualifications:

1. Utilize an installer having successfully completed concrete paver installation similar in design, material, and extent indicated on this project.

D. Mockups:
1. Install a 5 ft x 5 ft paver area.
2. Use this area to determine joint sizes, lines, laying pattern(s) and levelness. This area will serve as the standard by which the workmanship will be judged.
3. Subject to acceptance by owner, mock-up may be retained as part of finished work.
4. If mock-up is not retained, haul offsite and dispose legally.

1.05 DELIVERY, STORAGE & HANDLING

A. In accordance with Conditions of the Contract and Division 1 Product Requirement Section.

B. Deliver Permeable Concrete Pavers in manufacturer's original, unopened and undamaged container packaging with identification labels intact.

1. Coordinate delivery and paving schedule to minimize interference with normal use of streets and sidewalks adjacent to paver installation.
2. Deliver concrete pavers to the site in steel banded, plastic banded or plastic wrapped packaging capable of transfer by forklift or clamp lift.
3. Unload pavers at job site in such a manner that no damage occurs to the product or adjacent surfaces.

C. Store and protect materials free from mud, dirt and other foreign materials.

1.06 PROJECT/SITE CONDITIONS

A. Environmental Requirements:

1. Install permeable pavers only on unfrozen permeable setting bed aggregate materials.
2. Install permeable setting bed only on unfrozen permeable base and subbase aggregates.
3. Install permeable base or subbase aggregates only over unfrozen subgrade.

1.07 PERMEABLE CONCRETE PAVER OVERAGE AND ATTIC STOCK

A. Provide a minimum of 5% additional material for overage to be used during construction.

B. Furnish 100 square feet of each product and size used to owner for maintenance and repair. Furnish Permeable Concrete Pavers from the same production run as installed materials.

C. Manufacture to supply maintenance and reinstatement manuals for Permeable Concrete Paver units.

**PART 2 PRODUCTS**

2.01 PERMEABLE CONCRETE PAVERS

A. Basis-of-Design Product: The permeable concrete paver shapes are based on:

1. Unilock:

   a. Eco Promenade

2. As manufactured by:
   Unilock
   Uxbridge MA, Brewster NY, Rittman OH, Brighton MI, Aurora IL, Marengo IL, Elkhorn WI, Ayr ON, Georgetown ON, Pickering ON, Gormley ON
   Contact: Chicago- Brad Swanson – brad.swanson@unilock.com 630-742-4168
   New York - Mike Zengen – mike.zengen@unilock.com 845-538-7914
   Ontario – Dave Laurie – dave.laurie@unilock.com 416-805-6399

3. The specified products establish minimum requirements that substitutions must meet to be considered acceptable.

   a. To obtain acceptance of unspecified products, submit written requests at least 7 days before the Bid Date.

B. Product requirements:

1. Permeable Paver Type 1: Unilock Eco-Promenade
   a. Finish:

      1) Standard – this is not a face mix finish.

   b. Color: Steel Gray
   c. Edge: Chamfer - 3 mm rolled
   d. Size: 3x12”

C. Provide pavers meeting the minimum material and physical properties set forth in ASTM C 936, Standard Specification for Interlocking Concrete Paving Units. Efflorescence is not a cause for rejection.

1. Average compressive strength 8000 psi (55MPa) with no individual unit under 7,200 psi (50 MPa).
2. Average absorption of 5% with no unit greater than 7% when tested according to ASTM C 140.
3. Conforming to ASTM C 1645 when tested for freeze-thaw requirements.
4. Height tolerances +/- 3.2 mm (1/8 in).
   Note: Efflorescence is a whitish powder-like deposit that sometimes appears on concrete products. Calcium hydroxide and other water-soluble materials form or are present during the hydration of Portland cement. Pore water becomes saturated with these materials, and diffuses to the surface of the concrete. When this water evaporates, the soluble materials remain as a whitish deposit on the concrete surface. The calcium hydroxide is converted to calcium carbonate during a reaction with carbon dioxide from the atmosphere. The calcium carbonate is difficult to remove with water. However, the efflorescence will wear off with time, and it is advisable to wait a few months before attempting to remove any efflorescence. Commercially available cleaners can be used, provided directions are carefully followed. Some cleaners contain acids that may alter the color of the pavers.

D. Accept only pigments in concrete pavers conforming to ASTM C 979.
Note: ACI Report No. 212.3R provides guidance on the use of pigments.

E. Maximum allowable breakage of product is 5%.

2.02 PERMEABLE JOINT OPENING AGGREGATE

A. Provide Permeable Joint Opening Aggregate materials conforming to ASTM C 33 and gradation requirements of ASTM D 448 No. 8 as shown in Table 1. Unilock recommends using granite chips listed in table 2 below for vehicular areas with heavy traffic loads such as roadways or drive-through areas.

**TABLE 1 - ECO-OPTILOC**
**PERMEABLE JOINT OPENING AGGREGATE**
**GRADATION REQUIREMENTS**
**(CRUSHED LIMESTONE)**

| **ASTM No. 8** | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| 1/2 in (12.5 mm) | 100 |
| 3/8 in (9.5 mm) | 85 to 100 |
| No. 4 (4.75 mm) | 10 to 30 |
| No. 8 (2.36 mm) | 0 to 10 |
| No. 16 (1.18 mm) | 0 to 5 |

B. Provide Permeable Joint Opening Aggregate materials conforming to ASTM C 33 and gradation requirements as presented in Table 2.

1. Supplier:

a. Kafka Granite LLC Toll Free: 800-852-7415
b. Alliance Aqua-Roc
c. SEK Perm Chip

2. Color: (Specify granite chip color if other than crushed limestone)

**TABLE 2 - ECO-PRIORA & TOWN HALL**
**PERMEABLE JOINT OPENING AGGREGATE**
**GRADATION REQUIREMENTS**
**(GRANITE CHIPS)**

| ASTM No. 9 | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| 3/8 in (9.5 mm) | 100 |
| No. 4 (4.75 mm) | 85 to 100 |
| No. 8 (2.36 mm) | 10 to 40 |
| No. 16 (1.18 mm) | 0 to 10 |
| No. 50 (0.30 mm) | 0 to 5 |

2.03 PERMEABLE SETTING BED AGGREGATE

A. Provide Permeable Setting Bed Aggregate materials conforming to ASTM C 33 and gradation requirements of ASTM D 448 No. 8 as presented in Table 3.

**TABLE 3**
**PERMEABLE SETTING BED AGGREGATE**
**GRADATION REQUIREMENTS**

| ASTM No. 8 | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| ½ in (12.5 mm) | 100 |
| 3/8 in (9.5 mm) | 85 to 100 |
| No. 4 (4.75 mm) | 10 to 30 |
| No. 8 (2.36 mm) | 0 to 10 |
| No. 16 (1.18 mm) | 0 to 5 |

2.04 PERMEABLE BASE AGGREGATE

A. Provide Permeable Base Aggregate materials conforming to ASTM C 33 and gradation requirements of ASTM D 448 No. 57 as presented in Table 4.

**TABLE 4**
**PERMEABLE BASE AGGREGATE**

**GRADATION REQUIREMENTS**

| ASTM No. 57 | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| 1-1/2 in (37.5 mm) | 100 |
| 1 in (25 mm) | 95 to 100 |
| 1/2 in (12.5 mm) | 25 to 60 |
| No. 4 (4.75 mm) | 0 to 10 |
| No. 8 (2.36 mm) | 0 to 5 |

2.05 PERMEABLE SUBBASE AGGREGATE

A. Provide Permeable Subbase Aggregate materials conforming to ASTM C 33 and gradation requirements of ASTM D 448 No. 2 as presented in Table 5.

**TABLE 5**
**PERMEABLE SUBBASE AGGREGATE**
**GRADATION REQUIREMENTS**

| ASTM No. 2 | |
|---|---|
| **Sieve Size** | **Percent Passing** |
| 3 in (75 mm) | 100 |
| 2-1/2 in (63 mm) | 90 to 100 |
| 2 in (50 mm) | 35 to 70 |
| 1-1/2 in (37.5 mm) | 0 to 15 |
| 3/4 (19 mm) | 0 to 5 |

Note: For all aggregates, provide washed, clean, have zero plasticity, free from deleterious or foreign matter, crushed, angular rock and contain no No. 200 sieve size aggregate materials used in the construction of permeable pavement. Aggregate materials serve as the structural load bearing platform of the pavement as well as a temporary receptor for the infiltrated water that is collected through the openings in the pavement's surface.

2.06 GEOTEXTILE (Optional depending on soil conditions)

A. Provide Geotextile material conforming to the following performance characteristics, measured per the test methods referenced:

1. 4 oz., nonwoven needle punched geotextile composed of 100% polypropylene staple fibers that are inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.
2. Grab Tensile Strength: ASTM D 4632: 115 lbs.
3. Grab Tensile Elongation: ASTM D 4632: 50%
4. Trapezoidal Tear: ASTM D 4533: 50 lbs.
5. Puncture: ASTM D 4833: 65 lbs.
6. Apparent Opening Size: ASTM D 4751: 0.212 mm, 70 U.S. Sieve
7. Permittivity: ASTM D 4491: 2.0 sec -1
8. Flow Rate: ASTM D 4491: 140 gal/min/s.f.

B. As supplied by Unilock (add location, address, City, State and Zip)
Contact: (Insert Unilock representative name and phone number)

1. Carthage Mills – FX-40HS
2. U.S. Fabrics
3. Mirafi
4. Gator Fabric

2.07 EDGE RESTRAINTS

A. Concrete Edge Restraint as indicated.

B. Plastic and Metal Edge Restraints:

1. Permaloc, www.permaloc.com

    a. Material Type: Aluminum
    b. Model No.: 3 inch GeoEdge capture plate and geogrid

2. SEK Surebond

    a. Model No.: 8 feet PermEdge with attached geogrid

3. Snap Edge

    a. Material Type: Plastic
    b. Model No.: One Piece Edging, 96 inches

4. Pave Tech

    a. Material Type: Plastic
    b. Model No.: Pave Edge Rigid, Pave Edge Flexible, Pave Edge Industrial

5. Polybind Edge

    a. Material Type: Plastic
    a. Rigid 33
    b. Flex 34

6. Alliance Gator Edge

    a. Material Type: Plastic
    a. Rigid
    b. Flex

Note: The provision of suitable edge restraints is critical to the satisfactory performance of interlocking concrete block pavement. Abut pavers tightly against the restraints to prevent rotation under load and any consequent spreading of joints. Install sufficiently stable edge restraints that are, in addition to providing suitable edge support for the paver units, able to withstand the impact of temperature changes, vehicular traffic and/or snow removal equipment.

Curbs, gutters or curbed gutter, constructed to the dimensions of municipal standards (noting that these standards generally refer to cast-in-place concrete sections), are considered to be acceptable edge restraints for heavy duty installations. Where extremely heavy industrial equipment is involved such as container handling equipment, review the flexural strength of the edge restraint carefully particularly if a section that is flush with the surface is used and may be subjected to high point loading.

2.08 DriveGrid (Optional depending on project needs)

A. Provide Unilock DriveGrid geogrid.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Examine areas indicated to receive paving for compliance with requirements for installation tolerances and other conditions affecting performance for the following items before placing the Permeable Concrete Pavers.

1. Verify that subgrade preparation, compacted density and elevations conform to specified requirements.
2. Verify that Geotextiles, if applicable, have been placed according to drawings and specifications.
3. Verify that Permeable Base and Subbase Aggregate materials, thickness, compacted density, surface tolerances and elevations conform to specified requirements.
4. Provide written density test results for soil subgrade, Permeable Base and Subbase Aggregate materials to the Owner, General Contractor and paver installation subcontractor.
5. Verify location, type, and elevations of edge restraints, concrete collars around utility structures, and drainage inlets.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Beginning of bedding sand and paver installation signifies acceptance of base and edge restraints.

### 3.02 PREPARATION

A. Verify that the subgrade soil is free from standing water.

B. Stockpile Permeable Setting Bed, Joint, Base and Subbase Aggregate materials such that they are free from standing water, uniformly graded, free of any organic material or sediment, debris, and ready for placement.

C. Remove any excess thickness of soil applied over the excavated soil subgrade to trap sediment from adjacent construction activities before placing the Geotextile and Permeable Subbase Aggregate materials.

D. Keep area where pavement is to be constructed free from sediment during entire job. Remove and replace all Geotextile, Permeable Joint, Setting Bed, Base and Subbase Aggregate materials contaminated with sediment with clean materials.

E. Complete all subdrainage of underground services within the pavement area in conjunction with subgrade preparation and before the commencement of Permeable Subbase Aggregate construction.

F. Prevent damage to underdrain pipes, overflow pipes, observation wells, or inlets and other drainage appurtenances during installation. Report all damage immediately.

G. Compact soil subgrade uniformly to at least 90 percent of Standard Proctor Density per ASTM D 698 for pedestrian areas. Compact soil subgrade uniformly to at least 95 percent Modified Proctor per ASTM D 1557 for vehicular areas.

H. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting and replace with compacted backfill or fill as directed.

Note: Base compaction and proof-rolling of the subgrade soil on the recommendations of the Design Engineer. Request the Architect/Engineer to inspect subgrade preparations, elevations and conduct density tests for conformance to specifications.

Note: Mechanical tampers (jumping jacks) are recommended for compaction of soil subgrade and aggregate base around lamp standards, utility structures, building edges, curbs, tree wells and other protrusions. Compact areas, not accessible to roller compaction equipment, to the specified density with mechanical tampers. **CAUTION** – Proceed with care around the perimeters of excavations, buildings, curbs, etc. These areas are especially prone to consolidation and settlement. Do not place wedges of backfill in these areas. If possible particularly in these areas, proceed with backfilling and compacting in shallow lifts, parallel to the finished surface.

3.03 INSTALLATION

A. EDGE RESTRAINTS

1. Provide edge restraints as indicated.

   a. Install job-built concrete edge restraints to comply with requirements in Division 3 Section "Cast-in-Place Concrete."
   b. Provide concrete edge restraint along the perimeter of all paving as specified. Install the face of the concrete edge restraint, where it abuts pavers vertical down to the subbase.
   c. Construct concrete edge restraint to dimensions and level specified and support on a compacted subbase not less than 6 in (150 mm) thick.

2. Provide edge restraints as indicated.

B. GEOTEXTILES

1. Provide separation geotextile on bottom and sides of prepared soil subgrade. Secure in place to prevent wrinkling or folding from equipment tires and tracks.
2. Overlap ends and edges a minimum of 18 in. (450 mm) in the direction of drainage.

C. PERMEABLE BASE AND SUBBASE AGGREGATE

1. Provide the Permeable Subbase Aggregate in uniform lifts not exceeding 6 in., (150 mm) loose thickness and compact to at least 95 percent as per ASTM D 4254 to depths as indicated.
2. Compact the Permeable Subbase Aggregate material with at least two passes in the vibratory mode then at least two in the static mode with a minimum 10 ton vibratory roller until there is no visible movement. Do not crush aggregate with the roller.
3. Tolerance: Do not exceed the specified surface grade of the compacted Permeable Subbase Aggregate material more than ±3/4 in. (20 mm) over a 10 ft. (3 m) long straightedge laid in any direction.
4. Provide the Permeable Base Aggregate material in uniform lifts not exceeding 6 in. (150 mm) over the compacted Permeable Subbase Aggregate material and compact to at least 95 percent as per ASTM D 4254 to depths as indicated.

   a. As indicated, provide Unilock DriveGrid geogrid material.
   b. Place minimum 3 in. lift, compact Permeable Base Aggregate.
   c. Place Unilock DriveGrid geogrid material. Overlap ends and edges a minimum of 18 in. (450 mm).

5. Compact the Permeable Base Aggregate material with at least two passes in the vibratory mode then at least two in the static mode with a minimum 10 ton vibratory roller until there is no visible movement. Do not crush aggregate with the compaction device.
6. Tolerance: Do not exceed the specified surface grade of the compacted Permeable Base Aggregate material more than ±1/2 in. (13 mm) over a 10 ft. (3 m) long straightedge laid in any direction.
7. Grade and compact the upper surface of the Permeable Base Aggregate material sufficiently to prevent infiltration of the Permeable Setting Bed Aggregate material both during construction and throughout its service life.
   Note: In-place density of the Permeable Base and Subbase Aggregate materials may be checked per ASTM D 4254. Establish a Compacted density of 95% of the laboratory index density for the subbase and base stone.

D. PERMEABLE SETTING BED AGGREGATE

1. Provide, spread and screed Permeable Setting Bed aggregate evenly over the Permeable Base Aggregate course.

   a. Protect screeded Permeable Setting Bed Aggregate from being disturbed.
   b. Screed only the area which can be covered by pavers in one day.
   c. Do not use Permeable Setting Bed Aggregate material to fill depressions in the base surface.

2. Keep moisture content constant and density loose and constant until Concrete Pavers are set and compacted.
3. Inspect the Permeable Setting Bed Aggregate course prior to commencing the placement of the permeable concrete pavers.
4. Inspect the Setting Bed Aggregate course prior to commencing the placement of the Permeable Concrete Pavers. Acceptance of the Setting Bed Aggregate occurs with the initiation of Permeable Concrete Paver placement.

E. PERMEABLE CONCRETE PAVERS

1. Replace unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.
2. Mix Concrete Pavers from a minimum of three (3) bundles simultaneously drawing the paver vertically rather than horizontally, as they are placed, to produce uniform blend of colors and textures. (Color variation occurs with all concrete products. This phenomenon is influenced by a variety of factors, e.g. moisture content, curing conditions, different aggregates and, most commonly, from different production runs. By installing from a minimum of three (3) bundles simultaneously, variation in color is dispersed and blended throughout the project).
3. Exercise care in handling face mix pavers to prevent surfaces from contacting backs or edges of other units.
4. Provide Permeable Concrete Pavers using joint pattern as indicated. Adjust joint pattern at pavement edges such that cutting of edge pavers is minimized. Cut all pavers exposed to vehicular tires no smaller than one-third of a whole paver.
5. Use string lines or chalk lines on Permeable Setting Bed aggregate to hold all pattern lines true.
6. Set surface elevation of pavers 1/8 in. (3 mm) above adjacent drainage inlets, concrete collars or channels.
7. Place units hand tight against spacer bars. Adjust horizontal placement of laid pavers to align straight.

   a. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.

8. Provide space between paver units of 1/32 in. (1 mm) wide to achieve straight bond lines.
9. Prevent joint (bond) lines from shifting more than ±1/2 in. (±15 mm) over 50 ft. (15 m) from string lines.
10. Fill gaps between units or at edges of the paved area that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.
11. 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.
12. Prevent all traffic on installed pavers until Permeable Joint Aggregate has been vibrated into joints. Keep skid steer and forklift equipment off newly laid pavers that have not received initial compaction and Permeable Joint Aggregate material. .
13. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a to 5000-lbf (22-kN) compaction force at 80 to 90 Hz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:

   a. After edge pavers are installed and there is a completed surface.
   b. Compact installed concrete pavers to within 6 feet (1,800 mm) of the laying face before ending each day's work. Cover pavers that have not been compacted and leveling

course on which pavers have not been placed, with nonstaining plastic sheets to prevent Permeable Setting Bed Aggregate from becoming disturbed.

14. Protect face mix Concrete Paver surface from scuffing during compaction by utilizing a urethane pad.
15. Remove any cracked or structurally damaged pavers and replace with new units prior to installing Permeable Joint Opening Aggregate material.
16. Provide, spread and sweep Permeable Joint Opening Aggregate into joints immediately after vibrating pavers into Permeable Setting Bed course until full. Vibrate pavers and add Permeable Joint Aggregate material until joints are completely filled, then remove excess surface material.
17. Remove excess Permeable Joint Aggregate broom clean from surface when installation is complete.

Retain subparagraph above or below and detail on Drawings if pavers set in mortar or embedded in concrete are used as edge restraints for aggregate-set pavers.

3.04 FIELD QUALITY CONTROL

A. Verify final elevations for conformance to the drawings after sweeping the surface clean.

1. Prevent final Concrete Paver finished grade elevations from deviating more than ±3/8 in. (±10 mm) under a 10 ft (3 m) straightedge or indicated slope, for finished surface of paving.

B. Lippage: Paver-to-Paver Lippage:

1. No greater than 3 mm (1/8 inch) difference in height between adjacent pavers.
*Note: The industry standard acceptable lippage between adjacent pavers is 3 mm (1/8 inch). Achieving a completely flush paver surface is most desirable but may be unattainable depending on factors such as paver type, setting bed materials or depth, ASTM manufacturing standards or other specific project needs. Consult with your Unilock representative to determine the best approach for a reasonable lippage tolerance on each project.*

3.05 REPAIRING, CLEANING AND SEALING

A. Remove and replace unit 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.

B. Cleaning: Remove excess dirt, debris, stains, grit, etc. from exposed paver surfaces; wash and scrub clean.

1. Clean Permeable Concrete Pavers in accordance with the manufacturer’s written recommendations.

3.06 PROTECTION

A. Protect completed work from damage due to subsequent construction activity on the site.

3.07 PERMEABLE JOINT AGGREGATE MATERIAL REFILLING

A. Remove all debris from joint and provide additional Permeable Joint Aggregate material after 120 days and before 150 days after date of Substantial Completion/Provisional Acceptance.

1. Fill Permeable Joint Aggregate material full to the lip of the paver.

3.08 LIFE CYCLE ACTIVITIES

A. Paver cleaning: Clean Permeable Concrete Pavers as needed to remove staining, dirt, debris, etc.

1. Clean per manufacturers recommendations.

B. Maintenance: Permeable Joint Aggregate Material.

1. Annually inspect Permeable Joint Aggregate material for areas clogged with debris.
2. Vacuum or sweep as necessary to restore surface infiltration.
3. Remove debris by vacuuming or sweeping Permeable Joint Aggregate

a. Replenish removed Permeable Joint Aggregate material with clean aggregate material flush to paver lip.
b. Sweep excess material from paver surface.

**END OF SECTION 32 14 13.19**

SECTION 32 14 43- POROUS UNIT PAVING

PART 1- GENERAL

1.1 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.

1.2 ACTION SUBMITTALS

A. Product Data: For materials other than aggregates.

B. Sustainable Design Submittals

C. Sieve Analysis: 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.

4. Aggregate setting bed materials.

1.3 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.

**PART 2- PRODUCTS**

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or ARCOM. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements."

2.1 CONCRETE UNIT PAVERS

A. "Concrete Grid Pavers" Paragraph below applies to most standard grid paving units. ASTM C 1319 requires compressive strength of 5000 psi (35 MPa) and minimum thickness of 3-1/8 inches (80 mm). ASTM C 1319 contains no requirement for freeze-thaw resistance, only a requirement for durability based on three years' "proven field performance" in "the same general type of environment, temperature range, and traffic volume."

B. Concrete Grid Pavers: Grid paving units complying with ASTM C 1319, made from normal-weight aggregates.

Retain one thickness from options in "Thickness" Subparagraph below. Minimum thickness for pavers complying with ASTM C 1319 is 3-1/8 inches (80 mm). If grass or ground covers are used with pavers, units should be thick enough to provide adequate depth of soil fill.

1. Thickness: 3-7/8”
2. Face Size and Shape: 3x12 Standard Finish
3. Opening Percentage:
4. Color: Steel Gray

"Solid Concrete Pavers for Porous Paving" Paragraph below applies to standard solid concrete pavers that are shaped to provide drainage holes in the assembled pavement. Units complying with paragraph below will not provide as much open area as grid paving units complying with paragraph above and do not comply with requirements for porous paving for LEED-NC, LEED-CS, or LEED for Schools Credit SS 7.1, but they may help comply with LEED-NC, LEED-CS, or LEED for Schools Credit SS 6.1 and Credit SS 6.2. ASTM C 936/C 936M limits length-to-thickness ratio to no more than 4:1 (to provide interlocking effect); it limits face area to no more than 101 sq. in. (0.065 sq. m) and requires compressive strength of 8000 psi (55 MPa). ASTM C 936/C 936M requires units to be freeze-thaw resistant but gives manufacturer the option of either "proven field performance," which it does not define, or laboratory tests according to ASTM C 67. Revise paragraph below if units made from lightweight aggregates are required.

C. Solid Concrete Pavers for Porous Paving: Solid interlocking paving units of shapes that provide openings between units, complying with ASTM C 936/C 936M[, resistant to freezing and thawing when tested according to ASTM C 67], and made from normal-weight aggregates.

Retain one thickness from options in "Thickness" Subparagraph below. If grass or ground covers are used with pavers, units should be thick enough to provide adequate depth of soil fill.

1. Thickness: 3-7/8 inches
2. Face Size and Shape:3x12 standard finish
3. Opening Percentage
4. Color: Steel Gray

Retain "Color" Subparagraph below if edge restraints are installed above grade and color is a concern.

1. Color: [As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color>.

Aluminum edge restraints are generally installed below grade, so color is usually not a concern. Aluminum edging normally has a mill finish.

1.3 AGGREGATE SETTING-BED MATERIALS

A. "Graded Aggregate for Subbase" and "Graded Aggregate for Base Course" paragraphs below are examples of aggregate types and gradations that could be used where two layers are placed beneath leveling course. For heavy-duty applications, consult highway-department requirements and revise to suit Project. See the Evaluations.

First option in "Graded Aggregate for Subbase" Paragraph below is for light-traffic uses; second is for stormwater infiltration and storage; third is for heavy-duty applications. Delete paragraph if subbase is not required.

B. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with [ASTM D 448 for Size No. 57] [ASTM D 448 for Size No. 5] [ASTM D 2940/D 2940M, subbase material] [requirements in Section 312000 "Earth Moving" for subbase material].

First option in "Graded Aggregate for Base Course" Paragraph below is for light-traffic uses; second is for stormwater infiltration and storage; third is for heavy-duty applications.

C. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with [ASTM D 448 for Size No. 8] [ASTM D 448 for Size No. 57] [ASTM D 2940/D 2940M, base-course material] [requirements in Section 312000 "Earth Moving" for base-course material].

Generally, retain "Sand for Leveling Course" or "Soil Mix for Leveling Course" Paragraph below for grid paving units planted with grass or ground cover. Soil mix will not drain as well as sand, and may not support heavy loads as well as sand, but it will provide a better environment for plants.

D. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate.

E. Soil Mix for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate blended with planting soil <Insert drawing designation> according to [Section 329113 "Soil Preparation."] [Section 329115 "Soil Preparation (Performance Specification)."] Use blend consisting of [1/2 sand and 1/2 planting soil mix] [2/3 sand and 1/3 planting soil mix] <Insert proportions>.

"Graded Aggregate for Leveling Course" Paragraph below is recommended instead of "Sand for Leveling Course" or "Soil Mix for Leveling Course" Paragraph above for pavers used with aggregate fill. No. 8 stone is 1/2 inch (12.5 mm) and smaller; No. 9 is 3/8 inch (9.5 mm) and smaller.

F. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. [**8**] [**9**].

Retain "Drainage Geotextile" Paragraph below if nonwoven geotextile is used between aggregate base and leveling course. Also retain for use below aggregate base and subbase if porous paving is intended to provide stormwater infiltration into subgrade. Geotechnical report may also include geotextile recommendations.

G. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured according to test methods referenced:

Retain "Survivability" Subparagraph below if AASHTO M 288 survivability classification is required. Survivability classification rates a geotextile's ability to withstand installation stresses and is divided into three classes by AASHTO M 288. Class 2 is default class recommended by AASHTO M 288 for subsurface drainage applications. Revise to Class 1 if higher strength is required or to Class 3 if lower strength is permitted.

1. Survivability: Class 2; AASHTO M 288.

Requirements in "Apparent Opening Size," "Permittivity," and "UV Stability" subparagraphs below correspond to default values in AASHTO M 288 for Class 2 drainage geotextiles.

2. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D 4751.
3. Permittivity: 0.5 per second, minimum; ASTM D 4491.
4. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

## 2.4 FILL MATERIALS

Retain "Aggregate Fill for Porous Paving" Paragraph below for solid concrete pavers and for grid paving units used without planting. No. 8 stone is 1/2 inch (12.5 mm) and smaller; No. 9 is 3/8 inch (9.5 mm) and smaller.

B. Aggregate Fill for Porous Paving: Graded, sound, crushed stone or gravel complying with ASTM D 448 for Size No. [8] [9].

Retain "Color" Subparagraph below if a particular color is required.

1. Color: Steel Gray or equal

Retain "Grass Seed" Paragraph below for grid paving units used with grass.

C. Grass Seed: Comply with requirements in Section 329200 "Turf and Grasses."

# PART 3- EXECUTION

## 3.1 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. 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.

C. Tolerances:

1. Variation in Plane between Adjacent Units (Lipping): Do not exceed 1/16-inch (1.5-mm) unit-to-unit offset from flush.
2. Variation from Level or Indicated Slope: Do not exceed 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) or a maximum of 1/2 inch (13 mm).

D. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

## 3.2 SETTING-BED INSTALLATION

Retain first paragraph below if compaction is not specified in Section 312000 "Earth Moving." Coordinate with that Section to ensure that compaction for subgrade under concrete pavers is correctly specified. Paragraph below is an example only; revise to suit Project.

A. Compact subgrade uniformly to at least [95] <Insert number> percent of ASTM D 1557 laboratory density.

Revise overlap in first paragraph below to 24 or 36 inches (600 or 900 mm) for weak subgrade. Delete if geotextile is not required.

B. Place drainage geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 mm).

C. Place aggregate [subbase] [and] [base], compact by tamping with plate vibrator, and screed to depth indicated.

Retain first paragraph above or below or both unless subbase and base are specified in another Section. Retain above for light-traffic uses; retain below for heavy-duty applications. Delete subbase if not required. Paragraph below is an example only, although 100 percent compaction is usually easily achieved with highly granular materials used for base and subbase material with porous paving; revise to suit Project. ASTM D 1557 is generally used instead of ASTM D 698 for highly granular material when maximum compaction is required.

D. Place aggregate subbase and base, compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.

Retain first paragraph below if needed for open-graded subbase material to prevent base course from washing into subbase.

E. Place drainage geotextile over compacted subbase, overlapping ends and edges at least 12 inches (300 mm).

Retain first paragraph below for open-graded base-course material to prevent leveling course from washing into base course.

F. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 mm).

G. Place leveling course, and screed to a thickness of [2 to 2-1/2 inches (50 to 64 mm)] >, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

3.3 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. If pavers do not have lugs or spacer bars, place pavers with a 1/16-inch- (1.6-mm-) minimum and 1/8-inch- (3.2-mm-) maximum joint width.

B. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz.

Retain first two paragraphs below if porous paving is planted with grass. Retain first paragraph below if ground cover is used (ground covers are specified in Section 329300 "Plants").

C. Place soil fill immediately after vibrating pavers into leveling course. Spread and screed soil fill level with tops of pavers. Vibrate pavers and add soil fill until porous paving is filled to about 3/4 inch (19 mm) from top surface; remove excess soil fill if any.

D. After filling pavers with soil, sow seed according to Section 329200 "Turf and Grasses," except sow seed at half the rate specified for seeding lawns. Sweep seed from surfaces of pavers into voids and water with fine spray.

Retain first paragraph below if aggregates fill is used.

E. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.

F. 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.

3.4 MAINTENANCE AND PROTECTION

Retain this article if porous paving is planted with grass or ground cover. Retain first paragraph below only if pavers are planted with grass. Maintenance of ground covers after planting is specified in Section 329300 "Plants".

A. Water newly planted grass and keep moist until grass is established. Maintain grass that is planted in paving to comply with requirements in Section 329200 "Turf and Grasses."

B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades for [60] <Insert number> days after planting.

END OF SECTION 32 14 43

SECTION 32 84 00- LANDSCAPE IRRIGATION PREFORMANCE SPECIFICATION

**PART 1- GENERAL**

1.01 DESCRIPTION

A. It is the intent of this Specification that a finished system is complete in every respect and shall be ready for operation satisfactory to the Landscape Architect and Owner. The design is to be delegated by the contractor and approved by the Landscape Architect.

B. The work shall include all materials, labor, services, transportation, and equipment necessary to perform the work as indicated in these Specifications, and as necessary to complete the contract.

C. Section Includes:

1. Pipe and fittings, valves, outlets, backflow preventer, and accessories.

2. Connection to utilities and meter installation.

3. Automatic control system.

1.02 REFERENCES, DEFINITIONS AND APPLICABLE STANDARDS

A. ASTM D 1785 - Poly Vinyl Chloride (PVC) Plastic Pipe (SDR-PR)

B. ANSI/ASTM D 2564 - Solvent Cement for Poly Vinyl Chloride (PVC) Plastic Pipe and Fittings.

C. Reference and comply with applicable plumbing codes, standards, or specifications by building code or governing utility authority for the project location.

D. Rain Bird Irrigation Installation Details and Specifications.

E. Irrigation Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50V or for remote control, signaling power-limited circuits.

G. Notice of Completion: The date at the close of the Maintenance Period when the work has been completed, checked, accepted, and written approval of the work has been given by the Architect.

H. Date of Acceptance: The date at the end of the warranty periods as specified herein, and written acceptance has been given by the Architect.

I. Finish Grade: Elevation of finished surface of planting soil within 1/10th of an inch.

1.03 GENERAL SESIGN SYSTEM REQUIREMENTS

A. Contractor's delegated design for an automatic 2-wire system, electric valve, irrigation system with 100 percent coverage and minimal over spray onto buildings and paved surfaces to meet the following design standards:

1. Compliance with all applicable plumbing codes for the project location.

2. Irrigation water meter and tap to be provided as part of the irrigation system. Meter size and location to be determined by contractor’s system design and coordination with owner and general contractor.

3. General Contractor to provide irrigation system sleeving under pavement crossings at the locations and sizes shown in the irrigation shop drawings. Coordinate with General Contractor to provide any additional sleeves that may be necessary.

4. Provide backflow preventer assembly with insulated housing. Provide automatic controller, control wiring, and hardwired connections to power source. Coordinate controller location with owner, general contractor and electrical contractor.

5. Provide wireless rain and heat sensor device to shut off, delay, and adjust watering cycle times.

6. Pipe sizing must provide for a maximum velocity of 5 feet per second and must provide adequate pressure delivery at all heads for proper performance.

7. Provide separate valve zones for turf and planted bed areas.

8. Provide pop-up spray and/or rotor type outlets for turf areas.

9. Space spray and/or rotor type outlets to provide near 100% overlapped coverage between each outlet.

10. Provide drip irrigation for planted bed areas.

11. Provide drip pop up indicators at all drip areas.

12. Provide additional drip emitters for trees in drip zone areas.

13. Coordinate the locations of controller and backflow preventers to minimize visibility and screen with landscape materials where possible.

14. Piping to be located along back of curbs, pavement edges, and bed edges.

15. Spray from perimeter of areas where feasible.

16. Provide 100% coverage of all newly planted landscape areas on site and in adjacent street rights-of-way and/or other areas as indicated in the Landscape Plan.

17. Provide manual drain valves and sumps, or piped connections to drainage system in sufficient locations to drain the entire system for winterizing.

18. Provide valve boxes and covers at all locations described. Align all valve boxes parallel or perpendicular to adjacent hardscape where applicable.

19. Minimize the number of outlets, trenching, and pipe installation where possible.

1.04 PRE-CONSTRUCTION SUBMITTALS

A. Contractor to provide a delegated design for a fully automated 2- wire irrigation system to be reviewed and approved by the Landscape Architect through shop drawings.

B. Product Data:

1. Prior to ordering of any materials, and for each type of product indicated provide submittals for acceptance by the Landscape Architect. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. The submittals shall include the following information:

   a. A title sheet with the job name, the Contractor's name, address and telephone number, submittal date and submittal number.

   b. Shop Drawings with the following clearly indicated: Irrigation layout plan showing the sleeving locations, mainline routing, lateral line routing, controller location, meter location, backflow location and head or drip line locations.

   c. An index sheet showing the item number (i.e. 1, 2, 3, etc.); an item description (i.e. sprinkler head); the manufacturer's name (i.e. Rain Bird); the item model number (i.e. 44DLRC); and the page(s) in the submittal set that contain the catalog cuts.

   d. The catalog cuts shall clearly indicate the manufacturer's name and the item model number. The item model number, all specified options and specified sizes shall be circled or highlighted on the catalog cuts.

   e. Submittals for equipment shall contain the manufacturer, Class or Schedule, ASTM numbers and/or other certifications as indicated in these specifications.

3. Submittal Format Requirements:

   a. Submittals shall be provided as one complete package for the project. Multiple or partial submittal packages will not be reviewed.

   b. Submittal package shall be submitted as a single PDF file.

1.05 POST CONSTRUCTION SUBMITTALS

A. Record Drawings:

1. Record accurately on one set of drawings all changes in the work constituting departures from the original approved Shop Drawings and the actual final installed locations of all required components as shown below.

2. Record Drawings shall be prepared to the satisfaction of the Architect. Prior to final inspection of work, submit Record Drawings to the Architect.

3. Show locations and depths of the following items:

   a. Point of connection (including water POC, basket strainer, pressure regulator, master control valve, flow sensors, etc.)

   b. Routing of sprinkler pressure main lines (dimensions shown at a maximum of 100 feet along routing.)

   c. Isolation valves.

   d. Mainline air release valves.

e. Automatic remote-control valves (indicate station number and size).

f. Quick coupling valves.

g. Routing of control wires where separate from irrigation mainline.

h. Irrigation controllers

i. Related equipment (as directed)

B. Controller Charts:

1. Provide one controller chart for each automatic controller. Chart shall show the area covered by the controller. The areas covered by the individual control valves shall be indicated using colored highlighter pens. A minimum of six individual colors shall be used for the controller chart unless less than six control valves are indicated.

2. When completed and approved, the chart shall be hermetically sealed between two pieces of plastic, each piece being a minimum 20 mils in thickness. The contractor is to provide a minimum of three (3) copies to the owner

1.06 FIELD QUALITY CONTROL

A. Provide at least one English speaking person who shall be present at all times during execution of this portion of the work and who shall be thoroughly familiar with the type of materials being installed and the manufacturer's recommended methods of installation and who shall direct all work performed under this section.

B. Manufacturer's directions and detailed drawings shall be followed in all cases where the manufacturer of articles used in this contract furnish directions covering points not shown in the Specifications.

C. All local, municipal, and state laws, rules and regulations governing or relating to any portion of this work are hereby incorporated into and made a part of these specifications, and their provisions shall be carried out. Anything contained in these Specifications shall not be construed to conflict with any of the above rules and regulations of the same. However, when these Specifications call for or describe materials, workmanship, or construction of a better quality, higher standard, or larger size than is required by the above rules and regulations, the provisions of these Specifications shall take precedence

D. Materials supplied for this project shall be new and free from any defects. Defective materials shall be replaced immediately at no additional cost.

E. Secure the required licenses and permits including payments of charges and fees, give required notices to public authorities, verify permits secured or arrangements made by others affecting the work of this section.

F. Acquire certificate of compliance from local authority indicating approval of backflow preventer installation.

1.07 FIELD MEASUREMENTS

A. Verify that field conditions are as shown in the drawings. Revise design and record drawing as required.

1.08 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. Exercise care in handling, loading, unloading, and storing plastic pipe and fittings under cover until ready to install. Transport plastic pipe only on a vehicle with a bed long enough to allow the pipe to lay flat to avoid undue bending and concentrated external load.

C. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

D. Use all means necessary to protect irrigation system materials before, during, and after installation and to protect the installation work and materials of all other trades. In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Landscape Architect and at no additional cost.

1.09 PROJECT CONDITIONS

A. Verify and determine the locations, size and detail of points of connection provided as the source of water and electrical supply to the irrigation system.

B. Irrigation design shall be based on the available water pressure. Verify the dynamic water required is available on the project prior to the start of construction. Should a lack of pressure exist to achieve the flow necessary to operate the system, notify the Landscape Architect prior to beginning construction.

C. Prior to cutting into the soil, locate all cables, conduits, sewer septic tanks, and other utilities that are commonly encountered underground, and take proper precautions not to damage or disturb such improvements. If a conflict exists between such obstacles and the proposed work, promptly notify the Landscape Architect who will arrange for relocations. Proceed in the same manner if a rock layer or any other such conditions are encountered. Call in utility locates prior to all trenching or excavation.

D. Protect all existing utilities and features to remain on and adjacent to the project site during construction. Repair, at Contractor’s own cost; all damage resulting from Contractor’s operations or negligence.

E. Coordinate installation of required sleeving per approved Shop Drawings.

F. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied, unless permitted under the following conditions and then only after arranging to provide temporary water service according to the requirements indicated:

1. Notify Water Utility provider prior to Interruption.

2. Notify Architect no fewer than two working days (48 hours) in advance of proposed interruption of water service.

3. Do not proceed with interruption of water service without the Architect’s written permission.

1.10 GUARANTEE

A. The entire irrigation system, including all work done under this contract, shall be unconditionally guaranteed against all defects and fault of material and workmanship, including settling of backfilled areas below grade, for a period of one (1) year following the approved final acceptance.

B. Should any problem with the irrigation system be discovered within the guarantee period, it shall be corrected by the Contractor at no additional expense to the Owner within ten (10) calendar days of receipt of written notice from the Landscape Architect. When the nature of the repairs as determined by the Landscape Architect constitutes an emergency (i.e. broken mainline) the Landscape Architect may proceed to make repairs at the Contractor's expense. Damages to existing improvement resulting either from faulty materials or workmanship shall be repaired to the satisfaction of the Landscape Architect by the Contractor, all at no additional cost.

C. Manufacturer's warranties shall not relieve the Contractor of his liability under the guarantee. Such warranties shall only supplement the guarantee.

**PART 2- PRODUCTS**

2.1 APPROVED MANUFACTURERS

A. Rain Bird Corporation, Turf Division: For all irrigation system equipment and accessories.

B. NDS: For valve boxes.

C. Wilkins/Zurn: For backflow preventers

2.2 MATERIALS

A. Pipe:

1. PVC in accordance with ASTM D 1785: PVC Schedule 40 pipe for all sleeving, main lines, lateral lines, and fittings throughout system. Solvent-weld sockets.

2. Rigid copper pipe required from tap at public main through backflow preventer.

B. Fittings: Type and style of connection to match pipe.

C. Solvent Cement: ANSI/ASTM D 2564 for PVC pipe and fittings.

D. Tracer Wire: 14 AWG solid copper wire with insulating cover, to be tagged as “Tracer wire” with metal tags. Color of insulating cover must be different from other wiring.

2.3 MATERIALS

A. Turf Outlets:

1. Spray Outlets: Pop-up spray bodies, 6 inch minimum to 12 inch riser heights as needed for adequate performance, with installed check valves and pressure regulating devices.

2. Drip Emitters: Pressure Compensating drip emitters for additional water to tree placements within drip zones; one drip emitter for each ornamental size tree and two drip emitters for each medium or large size tree. Provide diffuser caps for each emitter.

2.4 BACKFLOW PREVENTERS

A. Controller: Automatic controller for electric valve operation sized for required number of stations, with grounding per manufacturer specifications and hardwired connections to power source.

B. Backflow Preventer: Wilkins/Zurn: 975XL or 975XLSEU backflow preventer sized for maximum flow in system with a maximum pressure loss limited to 10% of available residual pressure.

C. Backflow Preventer Housing: DekoRRa model 301/302, Class II, turf brown granite color, anchored to 4” minimum concrete base per manufacturer’s details and specifications. Provide minimum size to cover with insulation bag.

2.5 CONTROLS

A. Controller: Automatic controller for electric valve operation sized for required number of stations, with grounding per manufacturer specifications and hardwired connections to power source.

B. Controller Housing:

1. Indoor Installations: Wall mount plastic housing with lockable access door. Indoor installations must be able to accommodate wiring or wireless system remote operation of rain and heat sensing device. Coordinate with electrician for power source.

2. Outdoor Installations:

a. Wall Mount: Stainless steel housing with lockable access door.

b. Ground Mount: Stainless steel housing and pedestal with lockable access door.

C. Accessories: Include required fittings, galvanized metal electrical conduit, and accessories for installation.

D. Control Wiring: Gauge of wire to be sized by contractor for adequate operation of valves. Use waterproof connectors for all connections. Use different color wire jackets for valve power wires and white jacket for common wire.

E. System Grounding: Provide grounding at controller and throughout control wiring and valve layout to meet manufacturer's standards with grounding devices as recommended by manufacturer.

F. Rain and Heat Sensor Device: Wireless automatic, adjustable, shutoff device to disable/delay operations during or after recent rainfall and adjust watering cycle times for local heat and rainfall conditions. Provide and install connection equipment necessary for operation at controller.

2.6 OTHER EQUIPMENT

A. Swing Joints: Provide PVC pipe swing joints for all full circle rotor outlet placements.

B. Pressure Regulating Swing Joints: Provide pressure regulating PVC pipe swing joints for all rotor outlet placements without internal pressure regulation.

C. Valve Boxes and Covers: Valve boxes and covers required for all control valves, drip filters, drain valves, surge protector devices, wiring changes of direction, and wiring junctions.

D. Drip Filters: Replaceable and/or cleanable sized to match zone flows, installed with valve in valve box.

E. Drain Valves: Manual, PVC valves on tees for low points in system.

**PART 3- EXECUTION**

3.1 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.

B. Verify location of existing utilities. Repair utilities damaged as a result of this work at no increase in Contract Sum.

C. Verify that required utilities are available in proper location and ready for use.

D. Verify available water pressure at meter or backflow preventer locations.

E. Verify sleeve locations.

F. Beginning of installation means installer accepts existing conditions.

3.2 PREPARATION

A. Layout and stake locations of system components.

B. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system. Notify Architect/Engineer for approval of field changes to system design.

C. Coordinate location of controller, rain and heat sensor device, and connections to power source with Owner, General Contractor, and Electrical Contractor.

3.3 TRENCHING

A. Minimum Trench Depth: Trench depth must provide a minimum of 18 inches of cover over all main lines and wiring and 12 inches of cover over all lateral lines.

B. Trench to accommodate grade changes and slope to manual drain valves at low points in system.

C. Maintain trenches free of rocks, obstructions, or other debris that may damage pipe or wiring.

D. Repair or replace existing improvements damaged by work performed under this contract with equivalent materials or products.

3.4 INSTALLATION

A. Install irrigation sleeving under all pavement crossings and bury at a minimum depth of 18 inches below finish grade. All sleeving trenches must match finish grade and be compacted to minimum subgrade requirements for paving.

B. Install pipe, backflow preventer, valves, valve boxes, wiring, grounding, drains, controls, and outlets in accordance with all applicable plumbing codes, manufacturer's details, instructions, and minimum standards.

C. Trenches for irrigation main and lateral lines must match finish grade and be compacted to the degree that no settlement will occur.

D. Install cast concrete thrust blocking at all piping bends for 3 inch or larger pipe sizes.

E. Install zone valves with pressure regulating devices in valve boxes per manufacturer specifications and details. Provide metal tag with zone number for each valve.

F. After piping is installed but before sprinkler heads are installed and trenches backfilled, open valves and flush system with full head of water.

G. Install spray and rotor outlets with fittings, flex pipe, swing joints, etc. Use threaded connections to lateral lines. Install in accordance with manufacturer's details, instructions and minimum standards.

H. Install drip lines, emitters, filters, fittings, etc. in accordance with manufacturer's details, instructions and minimum standards. Anchor line with galvanized wire anchors at 3 feet on center, minimum spacing.

I. Install manual drain valves at system piping low points and pipe connections from valves to site drainage system, or, provide 12" diameter by 24" deep, gravel filled drain sumps where piped connections are not feasible.

J. Connect to water and electrical services.

K. Set outlets and box covers at finish grade elevations.

L. Install control wiring in trenches along with main lines to valves and provide 30-inch expansion coil at each valve and change of direction. Also provide 30-inch expansion coils at 100-foot intervals between valves.

M. Tracer Wire: Install tracer wire from gate valve at backflow preventer along all main lines to each zone valve. Terminate at valve boxes with 24” wire coil and metal tags labeled as “Tracer Wire.”

N. Install automatic controller. Provide hardwired connection to power source, enclose wiring to system and power source in rigid metal conduit where exposed. Paint exposed conduit to match building exterior.

O. Install rain and heat sensor device and wireless connection device to controller. Verify proper operation of device.

P. Program remote irrigation controller and install connection equipment necessary for operation at controller. Verify proper operation of remote.

Q. Repair or replace any other work or improvements damaged as a result of work related to system installation at no increase to the Contract Sum.

3.5 FIELD QUALITY CONTROL

A. Prior to backfilling and installation of outlets, cap or plug pipes and test system for leakage. Maintain maximum available pressure for one hour. Piping is acceptable if no leakage or loss of pressure occurs during test period.

3.6 ADJUSTING

A. Adjust control system to achieve time cycles required for adequate watering at time of installation.

B. Adjust heads and/or nozzles to achieve proper coverage and performance. Make nozzle or head changes as necessary for proper coverage.

C. Adjust zone valves for proper operating pressures at valve zones.

3.7 EXTRA MATERIALS

A. Furnish to Owner the following extra components:

1. Two sprinkler heads of each type and size.
2. Two nozzle inserts for each type and size.
3. Two drip emitters of each type and size
4. Two drip line basket filters of each type and size.
5. Two keys each for valve boxes and controller (if locked boxes are used).
6. Two of any required special tools for adjustment or replacement of each type of outlet, nozzle, valve, and other system equipment.

3.8 CLOSEOUT

A. Provide system demonstration to Owner and Architect/Engineer for review and final acceptance of work. Coordinate demonstration of procedures for winterizing (draining system lines, backflow preventer, etc.) and spring start-up with Owner. Review system operation and components during service visit.

B. Instruct Owner or representative in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance material as basis for demonstration.

C. Deliver record drawing of system, required operation and maintenance information, extra materials and backflow preventer certificate to Owner at the instruction meeting.

3.9 WARRANTY

A. Provide one-year materials and workmanship warranty on all system components and installation beginning on date of acceptance of the work.

B. Replace failed components immediately upon notification by Owner or Architect/Engineer.

END OF SECTION 32 84 00

SECTION 32 92 00- TURF GRASSES

PART 1- GENERAL

1.01 DESCRIPTION

A. Provide sodded lawns as shown and specified. The work includes:

1. Soil preparation.

2. Sodding lawns and other indicated areas.

3. Maintenance

1.02 QUALITY ASSURANCE

A. Sod: Comply with American Sod Producers Association (ASPA) classes of sod materials.

B. Provide and pay for materials testing. Testing agency shall be acceptable to the Architect. Provide the following data:

1. Test representative materials samples proposed for use.

2. Topsoil:

a. pH factor.

b. Mechanical Analysis

c. Percentage of organic content

d. Recommendations of type and quantity of additives required to establish satisfactory pH factor and supply of nutrients to bring nutrients to satisfactory level for planting.

1.03 SUBMITTALS

A. Submit sod growers certification of grass species. Identify source location.

B. Submit the following materials certification:

1. Fertilizer(s) analysis.

C. Submit materials test report.

D. Upon sodded lawn acceptance, submit written maintenance instructions recommending procedures for maintenance of sodded lawns.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Cut, deliver, and install sod within a 24-hour period.

1. Do not harvest or transport sod when moisture content may adversely affect sod survival.

2. Protect sod from sun, wind, and dehydration prior to installation.

3. Do not tear, stretch, or drop sod during handling and installation.

1.05 PROJECT CONDITIONS

A. Work notification: Notify Architect at least 7 working days prior to start of sodding operations.

B. Protect existing utilities, paving, and other facilities from damage caused by sodding operations.

C. Perform sodding work only after planting and other work affecting ground surface has been completed.

D. Restrict traffic from lawn areas until grass is established. Erect signs and barriers as required.

E. Provide hoses and lawn watering equipment as required.

1.06 WARRANTY

A. Provide a uniform stand of grass by watering, mowing, and maintaining lawn areas until final acceptance. Re sod areas, with specified materials, which fail to provide a uniform stand of grass until all affected areas are accepted by the Landscape Architect.

PART 2- PRODUCTS

2.01 MATERIALS

A. Reference plan for turf material type.

B. Provide well-rooted, healthy sod, free of diseases, nematodes and soil borne insects. Provide sod uniform in color, leaf texture, density, and free of weeds, undesirable grasses, stones, roots, thatch, and extraneous material; viable and capable of growth and development when planted.

C. Fertilizer:

1. Granular, non-burning product composed of not less than 50% organic slow acting, guaranteed analysis professional fertilizer.

a. 8-8-8

b. 10-10-10

D. Water: Will be may not be available on site. Landscape contractor will provide necessary hoses and other watering equipment required to maintain and complete work. An auto-matic/drip irrigation system will be installed simultaneously with the landscape planting. The landscape contractor shall not anticipate the use of the irrigation system during installation of this contract.

PART 3- EXECUTION

3.01 INSPECTION

A. Examine finish surfaces, grades, topsoil quality, and depth. Do not start sodding work until unsat-isfactory conditions are corrected.

3.02 PREPARATION

A. Limit preparation to areas which will be immediately sodded.

B. Loosen topsoil of lawn areas to minimum depth of 4". Remove stones over 1" in any dimension and sticks, roots, rubbish, and extraneous matter.

C. Grade lawn areas to smooth, free draining and even surface with a loose, uniformly fine texture. Roll and rake; remove ridges and fill depressions as required to drain.

D. Apply Type A fertilizer at the rate equal to 1.0 lb. of actual nitrogen per 1,000 sq. ft. (220 lbs./acre). Apply fertilizer by mechanical rotary or drop type distributor, thoroughly and evenly incorporated with the soil to a depth of 3" by disking or other approved methods. Fertilize areas inaccessible to power equipment with hand tools and incorporate it into soil. Buffalo Grass Sod may not require fertilizer submit soil test for review by Landscape Architect.

E. Dampen dry soil prior to sodding.

F. Restore prepared areas to specified condition if eroded, settled, or otherwise disturbed after fine grading and prior to sodding.

## 3.03 INSTALLATION

A. Sodding:

1. Lay sod per plans to form a solid mass with tightly-fitted joints. Butt ends and sides of sod strips. Do not overlay edges. Stagger strips to offset joints in adjacent courses. Remove excess sod to avoid smothering of adjacent grass. Provide sod pad top flush with adjacent curbs, sidewalks, drains, and seeded areas.
2. Do not lay dormant sod or install sod on saturated or frozen soil.
3. Install initial row of sod in a straight line, beginning at bottom of slopes, perpendicular to direction of the sloped area. Place subsequent rows parallel to and lightly against previously installed row.
4. Peg sod on slopes greater than 3 to 1 to prevent slippage at a rate of 2 stakes per yd. of sod.
5. Water sod thoroughly with a fine spray immediately after laying.
6. Roll with light lawn roller to ensure contact with sub-grade.

B. Sod indicated areas within contract limits and areas adjoining contract limits disturbed as a result of construction operations.

## 3.04 MAINTENENACE

A. Maintain sodded lawn areas, including watering, spot weeding, mowing, application of herbicides, fungicides, insecticides and resodding until a full, uniform stand of grass free of weed, undesirable grass species, disease, and insects is achieved and accepted by the Architect at the completion and acceptance of the entire project.

1. Water sod thoroughly every 2 to 3 days, or as required to establish proper rooting.
2. Repair, rework, and resod all areas that have washed out or are eroded. Replace undesirable or dead areas with new sod.
3. Mow lawn areas as soon as lawn top growth reaches a 3" height. Cut back to 2" height. Repeat mowing as required to maintain specified height. Not more than 40% of grass leaf shall be removed at any single mowing.
4. Apply Type B fertilizer to lawns approximately 30 days after sodding at a rate equal to 2.0 lbs. of actual nitrogen per 1,000 sq. ft. (140 lbs./acre). Apply with a mechanical rotary or drop type distributor. Thoroughly water into soil. *Only as required per soil test for Buffalo Sod

5. Apply herbicides as required to control weed growth or undesirable grass species.

6. Apply fungicides and insecticides as required to control diseases and insects.

3.05 ACCEPTANCE

A. Inspection to determine acceptance of sodded lawns will be made by the Architect, upon contractor's request at the completion of the entire project. Provide notification at least 10 working days before required inspection date.

1. Sodded areas will be acceptable provided all requirements, including maintenance, have been complied with, and a healthy, even colored viable lawn is established, free of weeds, undesirable grass species, disease, and insects.

B. Upon final acceptance, the Owner will assume lawn maintenance.

3.06 CLEANING

A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, debris, and equipment. Repair damage resulting from sodding operations.

END OF SECTION 32 92 00

SECTION 329300- EXTERIOR PLANTS

PART 1- GENERAL

1.01 DESCRIPTION

A. Work Included: Provide trees, shrubs, ground covers, native perennials, native grasses and native wildflower and grass seed as shown and specified.

1. Soil preparation.

2. Trees, shrubs, groundcovers, native perennials and native grasses.

3. Planting mixes.

4. Mulch and planting accessories.

5. Maintenance and Extended Management.

B. Related Work:

1. Section 01 5713: Temporary Erosion and Sediment Control

2. Section 32 8400: Planting Irrigation

3. Section 32 9200: Turf Grasses

4. Section 32 9400: Landscape Planting Accessories

5. Section 31 2100: Finish Grading

6. Section 32 9400: Soil Preparation

C. Definitions:

1. Plant Material(s) – Refers to living plant species, inclusive of trees, shrubs, groundcovers, vines, ornamental grasses, cacti/succulents, espaliers, annuals, perennials, etc., as indicated in the Contract Drawings.

2. Planting Area (PA) – As denoted on the Contract Drawings, shall refer to areas to be installed with Plant Material(s), or areas where existing vegetation shall be protected.

3. Plant Height – Measurement of main body height, not measurement to branch tip.

4. Plant Spread – Measurement of main body diameter, not measurement from branch tip to branch tip.

5. Amended Planting Backfill Mixture – Refer to Section 32 91 13 – Soil Preparation.

6. Balled and Burlapped Stock – Healthy, vigorous exterior plants with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum laced as recommended by ANSI Z60.1.

7. Balled and Potted Stock – Healthy, vigorous exterior 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 exterior plant required.

8. Bare-Root Stock – Healthy, vigorous exterior plants grown 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 exterior plant required.

9. Compacted Settling Layer – Subgrade under where a plant is directly planted.

10. Container-Grown Stock – Healthy, vigorous, well-rooted exterior plants grown in a container with 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 exterior plant required.

11. Fabric Bag-Grown Stock – Healthy, vigorous, well-rooted exterior plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of exterior plant.

12. Finish Grade – Elevation of finished surface of planting soil.

13. Manufactured Topsoil – Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

14. Multi-Stem – Where three (3) or more main stems arise from the ground from a single root crown or at a point right above the root crown.

15. Sub-grade – Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

16. Subsoil – All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.

1.02 QUALITY ASSURANCE

A. Installer Qualifications:

1. Requirement: Valid Arkansas Landscaping Contractor License.

2. Engage an experienced Installer who has demonstrated completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment.

3. Installer's Field Supervision: Installer shall maintain an experienced full-time supervisor on the Project site during times that landscaping installations under this Section are in progress.

4. Selections of Plant Material may be sourced and purchased by the Owner directly. Contractor to provide a line item installation cost and separate warranty identifying the schedule of values for each.

B. Plant Material:

1. Trees, Shrubs, Grasses and Seed: Provide quality, size, genus, species, and variety of Plant Material indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock."

a. At least one (1) plant of each Plant Material species delivered to the Project Site shall have an identification tag from supplying nursery showing botanical and common name of the plant as identified in the Contract Drawings. Landscape Architect shall be provided the opportunity for an on-site debriefing by the Contractor that identifies the size and specific type of Plant Material upon delivery.

1) Incorrect Planting Materials:

a) Replace, at no cost to Owner, Plant Material that is revealed during the course of the Contract as to being untrue to the species indicated in the Contract Drawings and reviewed accordingly under this Section.

b) Provide replacements equal to the size and quality to match the planted materials at the time the untrue species is discovered.

2) Replacement of Plant Material: Refer to the Guarantee Article indicated herein this Section.

2. Native Wildflower and Grass seed: Provide quality seed and/or custom mix identified within the Construction Documents. Noxious weed seeds shall not exceed one-half (1/2) percent by weight of the total of pure live seed and other material in the mixture. Johnson Grass, nutgrass or other noxious weed seed will not be allowed.

a. At least one-half (1/2) pound of each seed/seed mix species delivered to the Project Site shall have an identification tag from supplying nursery showing botanical and common name of the plant as identified in the Contract Drawings. Landscape Architect shall be provided the opportunity for an on-site debriefing by the Contractor to verify the species of seed upon delivery.

1) Incorrect Seed Materials:

a) Replace, at no cost to Owner, Seed that is revealed during the course of the Contract as to being untrue to the species indicated in the Contract Drawings and reviewed accordingly under this Section.

b) Provide replacement seed at the time the untrue species is discovered.

2) Replacement of Plant Material: Refer to the Guarantee Article indicated herein this Section.

C. Observation: Landscape Architect may observe Plant Materials at their place of growth (nursery), at the site before or after planting, or both, for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect also retains right to observe Plant Material further for size and condition of root balls, trunks, branches, and crowns; insects; pests; disease; weeds; injuries, and latent defects. Landscape Architect reserves the right to reject unsatisfactory and/or defective Plant Material at any time during progress of Work. Contractor shall remove rejected Plant Material immediately from Project site.

D. Regulatory Requirements:

1. Contractor shall meet the requirements of applicable laws, codes, and regulations as required by the authorities having jurisdiction over the Work. Plant names indicated, comply with "Standardized Plant Names" as adopted by the latest edition of the American Joint Committee of Horticultural Nomenclature. Names of varieties not listed conform generally with names accepted by the nursery trade. Provide stock true to botanical name and legibly tagged.

E. Permits, Fees, Bonds, and Inspections: Contractor shall arrange and pay for permits, fees, bonds, and inspections necessary to perform and complete Work under this Section.

F. Plant Material Review and Selection (Tagging):

1. At the discretion of the Landscape Architect, Plant Material will be subject to review, photographed, and selected/tagged by the Landscape Architect at the nursery, or other place of growth, prior to delivery to the Project Site. Contractor shall verify with the Landscape Architect if tagging operations are required.

2. Selecting/Tagging of Plant Materials at the nursery or place of growth does not cancel the right of the Landscape Architect to reject Plant Materials at the Project Site, if damaged or unacceptable conditions are found that were not detected at the nursery, place of growth, or in the submitted photographs.

G. Plant Material Delivery: Plant Material shall be delivered with original Plant Material tagging materials set in place, as selected, and marked by the Landscape Architect at the nursery or place of growth. Seed, topdressing, and any fertilizer materials shall be delivered in original containers. Include materials showing weight, analysis, and names of growers. Store all seed material in a manner to prevent wetting, excessive heating, or other deterioration. Contractor shall notify Landscape Architect upon delivery of Plant Material for review of stock and tagging materials. Plant Materials delivered without original tagging materials, or with broken, damaged, or altered tagging materials, shall be subject to rejection by the Landscape Architect. Rejected Plant Material shall be removed immediately.

H. Pre-installation Conference: Conduct conference at Project Site.

I. Protection of Existing Plant Material:

1. Refer to Requirements specified in Section 015639 – Temporary Tree and Plant Protection.

2. It is the intent of the Contract Documents that certain existing Plant Materials shall be retained. Prior to the removal of any Plant Materials, the Contractor shall confer with the Landscape Architect to determine which Plant Materials are to remain.

3. All existing Plant Materials which are to remain in the project shall be tagged and identified by the Contractor prior to start of Work.

4. Contractor shall be responsible for Plant Materials that are designated to remain. Damage to any Plant Materials which results in death or permanent disfiguration of said Materials shall result in compensation outlined in Section 01 56 39 – Temporary Tree and Plant Protection. The Landscape Architect shall be the sole judge of the condition of the Plant Materials.

5. Existing Plant Materials designated to remain shall be protected at all times from damage by construction activity (tools, materials, equipment, personnel, etc.). Damage by the Contractor to existing Plant Materials shall be repaired at the Contractor's expense to the satisfaction of the Owner, as directed by the Landscape Architect.

6. Contractor shall insure that no foreign material and/or liquid, such as paint, concrete, cement, oil, turpentine, acid or the like, be deposited or allowed to be deposited on soil within the drip line (the outside edge of the foliage overhang) of any Plant Material. Do not store construction materials, debris, or excavated material within drip line of existing Plant Material. Should any such poisoning of the soil occur, the Contractor shall thoroughly remove said soil as directed by the Landscape Architect and replace with acceptable soil at no additional cost to the owner.

7. Excavation adjacent to existing Plant Materials: Where it is necessary to excavate in close proximity to the drip lines of existing Plant Materials, all possible caution shall be exercised to avoid injury to roots and trunk. Excavation close to Plant Materials shall be done by hand, with narrow-tine spading forks or other approved tools to comb soil to expose roots. Tunnel under roots two-inches (2") and larger in diameter. Cutting of roots two-inches (2") and larger shall be only on the approval of the Landscape Architect.

8. Replacement of Damaged Plant Material: Replace existing Plant Material to remain as required, hat are damaged by Contractor during construction with accepted Plant Material of the same species, size, and quantity as those damaged, at no additional cost to Owner. Owner shall be the sole judge as to the extent of the damage and the value of said damaged Plant Material.

1.03 SUBMITTALS

A. General:

1. Collect information into a single submittal.

2. Submittal shall be organized and presented into specific sections or headings. Furnish neat, concise, legible, and clearly identifiable information, and sufficiently explicit detail, to enable proper evaluation for Contract compliance. Highlight catalog, product data, or brochures containing various products, sizes, and materials to show particular item submitted.

3. Submittal Format: As applicable, furnish Submittal as a single electronic digital PDF (Portable Document Format) file.

B. Digital Submittal Information:

1. Alphabetized List of Plant Material.

2. Submitted in the following format.

a. Project Name
b. Botanical Name
c. Common Name
d. Container Size
e. Overall Height
f. Caliper Size
g. Quantity

3. The submittal shall not be construed as to acceptance of the plant material. All plant material shall be subject to review and approval by the Landscape Architect upon delivery to the project site.

C. No work shall proceed under this Section until submittal requirements indicated herein have been reviewed accordingly by the Landscape Architect.

D. Provide plant material record drawings:

1. Legibly mark drawings to record actual construction.

2. Indicate horizontal and vertical locations, referenced to permanent surface improvements.

3. Identify field changes of dimension and detail and changes made by Change Order.

E. Submit for the Landscape Architect's approval five samples of each container grown plant under the number 15 container size. The five approved samples shall be retained in a protected location on the project site at a location approved by the General Contractor. The Landscape Contractor shall maintain the sample plants until completion of the site planting. The sample plants may then be used in the site planting.

1.04 DELIVERY, STORAGE, AND HANDLING

A. General: Do not prune Plant Material before delivery, except as approved by the Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie Plant Material in such a manner as to destroy natural shape.

1. Immediately after digging field-grown Plant Materials, pack root systems in wet straw, hay, burlap, or other suitable material to keep root system moist until final planting installation.

2. Deliver freshly dug field-grown Plant Materials with firm, natural balls of earth of sufficient depth to include fibrous and feeding roots, meeting, or exceeding requirements of ANSI Z60.1 for root ball diameter.

3. Sore all seed material in a manner to prevent wetting, excessive heat, or other deterioration.

B. Handling Plant Materials:

1. Handle balled and burlap Plant Material stock by the root ball.

2. Handle container-grown Plant Materials only by their containers.

3. DO NOT handle Plant Materials by their trunks or stems.

4. DO NOT drop any Plant Materials.

5. DO NOT bind or handle Plant Materials with wire or rope.

6. Pad trunk and branches of Plant Materials whenever using hoisting cables, chains, or straps.

7. Should the Contractor engage in handling any Plant Material(s) by any unacceptable method(s), the Landscape Architect shall reserve the right to reject any of the mishandled Plant Material(s). The Contractor shall replace rejected Plant Material(s) with approved Plant Material(s), at no additional cost to the Owner.

C. Delivery: Provide protective covering during delivery. Deliver Plant Material only after preparations for planting have been completed and install immediately. If planting is delayed more than six (6) hours after delivery, set Plant Materials in shade, protect from weather and mechanical damage, and keep roots moist. Anchor plants to prevent damage from winds.

1. Heel-in bare-root Plant Material stock. Soak roots in water for two (2) hours prior to planting.

2. Set balled Plant Material stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.

3. DO NOT remove container-grown Plant Material stock from containers before time of planting.

4. Water root systems of Plant Material stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.05 PROJECT CONDITIONS

A. Work notification: Notify Architect at least 7 working days prior to installation of plant material.

B. Protect existing utilities, paving, and other facilities from damage caused by landscaping operations.

C. A complete list of plants, including a schedule of sizes, quantities, and other requirements is shown on the drawings. In the event that quantity discrepancies or material omissions occur in the plant materials list, the planting plans shall govern.

1.06 WARRANTY

A. Warrant plant material to remain alive and be in healthy, vigorous condition for a period of 1 year after completion and acceptance of entire project.

1. A review of plants will be made by the Architect at Substantial Completion and Final Completion.

B. Replace, in accordance with the drawings and specifications, all plants that are dead or, as determined by the Architect, are in an unhealthy or unsightly condition, and have lost their natural shape due to dead branches, or other causes such as bark abrasions and misuse of chemicals, due to the Landscape Contractor's negligence. The cost of such replacement(s) is at Landscape Contractor's expense. Warrant all replacement plants for 1 year after installation.

C. Warranty shall not include damage or loss of trees, plants, or ground covers caused by fires, floods, freezing rains, lightning storms, or winds over 75 miles per hour, winter kill caused by extreme cold and severe winter conditions not typical of planting area, acts of vandalism or negligence on the part of the owner.

D. Remove and immediately replace all plants, as determined by the Architect, to be unsatisfactory during the initial planting installation.

PART 2- PROJECTS

2.01 MATERIALS

A. Immediately upon award of Contract for Work in this Section, Contractor shall locate and purchase or hold for purchase plant material as required.

1. Contractor shall verify with Landscape Architect of Plant Material that has been nursery “contract grown” by the Owner for use of Work under this Contract.

2. Contractor shall review the condition of the Plant Material with Landscape Architect at the nursery maintaining the Plant Material prior to delivery, and when delivered to the Project Site.

B. Quality: Plant Materials shall have a growth habit typical for each variety and species indicated in the Plant List (as detailed on the Contract Drawings).

1. All Plant Materials specified shall be superior/premium-grade nursery stock, full, densely foliated, symmetrical, with tightly knit branching, so trained or favored in development and appearance in form, number of branches, compactness and symmetry, healthy, and vigorous in growth, as reviewed and determined by the Landscape Architect.

2. Plant Materials shall be free from insect pests, eggs and larvae, plant diseases, sun scalds, fresh bark abrasions, excessive abrasions, windburn, salt burn, weeds, or other disfigurements or conditions, as reviewed and determined by the Landscape Architect.

3. Plant Material shall be subject per the Arkansas State Department of Agriculture’s Regulations for Nursery Inspections of Rules and Grading.

4. Growing Conditions: Plant Materials shall be nursery-grown in accordance with good horticultural practices under climatic conditions similar to those of project unless otherwise specifically authorized.

C. Container Stock (excluding annuals) shall be grown in boxes or containers in which delivered for at least one (1) growing season, but not over two (2) years. Plant Material grown in boxes or containers shall be cultivated during this time to permit full rooting within the specified box or container to bind the planting soil, but not so long as to create a “root-bound” condition.

1. Plant Material shall be completely free of circling, kinked or girdling trunk surface and center roots, and show no evidence of a pot-bound condition.

2. No boxed nor container Plant Material shall be planted which have cracked or broken balls of earth when separated from their boxes or containers.

3. No Plant Material shall be planted with damaged roots, broken root balls, or which are found to be “root-bound” when separated from their containers.

D. Pruning:

1. Do not prune Plant Materials unless directed by the Landscape Architect.

2. Pruning of Plant Material as grown at the nursery shall conform to ANSI A300 Standards.

3. Consult with Landscape Architect for pruning Plant Materials after delivery and installation.

E. Measurements: Measure Plant Material according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes.

1. Take caliper measurement at a point on the trunk six-inches (6”) above natural ground line for trees up to four-inches (4”) in caliper (at a point twelve-inches (12”) above the natural ground line for trees over four-inches (4”) in caliper).

a. Measure foliage across mean foliage dimension when branches are in their normal upright position.

b. For trees to be supplied in “raised up” condition, foliage origin along main trunk shall be measured from soil line after installation.

c. Height and spread dimensions specified refer to main body of plant and not branch tip to tip. Properly trimmed plants shall measure the same in any direction. If a plant is unevenly grown, it shall be classified in the size category of the smallest dimension.

2. Size Range: If a range of size is given, do not use Plant Materials less than the minimum size. The measurements specified are the minimum size acceptable and are the measurements after pruning, where pruning is required. Plant Materials that meet the measurements specified, but do not possess a normal balance between height and spread shall be rejected.

F. Field Dug Stock: Prior to digging of field-grown Plant Materials, ensure that excess loose fill resulting from cultivation around trunks/stems and over roots be removed down to natural finish grade at crown of Plant Materials. During digging, verify that size of tree spade or other equipment is adequate to encompass the actively growing root zone of all Plant Materials. Plant Materials which, after digging, show mostly large fleshy roots and few fibrous roots, will be rejected.

G. Condition of Root Systems: Plant Materials must prove to be completely free of circling, kinked or girdling trunk surface and center roots and show no evidence of a root-bound condition. Upon inspection by Landscape Architect at the job site, if five-percent (5%) or more of the plants of each species are found to contain kinked, circling or girdling roots, all plants of that species shall be rejected.

H. Unacceptable Trees: Trees that have damaged, broken, pruned, or crooked leaders will be rejected. Trees having a main leader shall not have been headed back. Trees with abrasions of the bark, sunscalds, disfiguring knots, or fresh cuts of limbs over 3/4 in. which have not completely callused will be rejected.

2.02 TREES

A. Shade and Flowering Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required, subject to review and acceptance by the Landscape Architect. Container-grown trees will be acceptable and shall be subject to meeting ANSI Z60.1 limitation for container stock.

1. Branching Height: 1/2 of tree height, unless otherwise indicated on Contract Drawings.

B. Small Trees: Small upright or spreading type, branched, or pruned naturally according to species and type, and with relationship of caliper, height, and branching recommended by ANSI Z60.1, subject to review and acceptance by the Landscape Architect. Container-grown trees will be acceptable and shall be subject to meeting ANSI Z60.1 limitation for container stock.

1. Form: As indicated on the Contract Drawings for individual selected species.

C. Field Dug Specimen Trees:

1. Form and Size: As specified on the Contract Documents for height, spread, and/or caliper, subject to review and acceptance by the Landscape Architect at the supplying nursery prior to delivery and installation. Provide superior quality, full, symmetrical, well-rooted, upright, spreading, with well-balanced crown.

2. Throughout the duration of excavation, transport, delivery, storage, and installation, all Field Dug Specimen Trees shall have their root balls remain moist, firm and intact, with no damage. Provide metal cages, as required, to insure root ball stability. Any tree that exhibits a broken, damaged, or dry root ball at any time under the Contract shall be subject to immediate rejection by the Landscape Architect.

2.03 SHRUBS

A. Form and Size: Shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of Shrub, subject to review and acceptance by the Landscape Architect. Container-grown Shrubs will be acceptable in lieu of balled and burlapped.

1. Container-grown Shrubs shall be subject to meeting ANSI Z60.1 limitations for container stock, and other requirements as indicated on the Contract Drawings.

2.04 CONIFEROUS EVERGREENS

A. Form and Size: Normal-quality, well-balanced, well-rooted, coniferous evergreens, of type, height, spread, and shape required, subject to review and acceptance by the Landscape Architect.

1. Boxed or container-grown coniferous evergreens will subject to meeting ANSI Z60.1 limitations for container stock, and other requirements as indicated on the Contract Drawings.

2.05 BROADLEAF EVERGREENS

A. Form and Size: Normal-quality, well-balanced, well-rooted , broadleaf evergreens, of type, height, spread, and shape required, subject to review and acceptance by the Landscape Architect.

1. Container-grown broadleaf evergreens shall be subject to meeting ANSI Z60.1 limitations for container stock, and other requirements as indicated on the Contract Drawings.

2.06 GROUNDCOVERS

A. Provide ground covers full, established, and well-rooted in removable flats, containers, or integral peat pots, and with not less than the minimum number and length of runners required by ANSI Z60.1 for the container size indicated, and other requirements as indicated on the Contract Drawings, subject to review and acceptance by the Landscape Architect.

2.07 NATIVE GRASSES AND PLUGS

A. Form and Size: High-quality, established, full, well-balanced, well-rooted, of type, height, spread, and shape required, subject to review and acceptance by the Landscape Architect.

1. Container-grown stock shall be subject to meeting ANSI Z60.1 limitations for container stock.

2.08 PERMANENT SEEDING

A. Quantity/Weight per plans. An approved combination of Wildflower Seeds and Native Grass seed shall be supplied as custom mixes identified within the Construction Documents. Procure local genotype seed when and if available. Seed must be collected by lawful means and must come from a similar geographic region.

2.09 ACCESSORIES

A. Reference – Section 32 94 00 Landscape Planting Accessories.

2.10 PLANT LIST

A. The plant list including quantities is located on the plans and is for reference only. It is the responsibility of the contractor to determine total quantities in conformance with the plans. Height of plants specified and height of lowest branches of trees is above soil line.

PART 3 – EXECUTION

3.01 INSPECTION

A. No work under this section shall commence until submittals under this section have been reviewed accordingly by the Landscape Architect.

B. Prior to commencing Work under this Section, Contractor shall examine previously installed Work from other trades and verify that such Work is complete and to the point where Work herein may commence properly. Do not proceed with Work until unsatisfactory conditions have been corrected.

C. Installation practices of the Plant Materials shall be performed during those periods when weather and soil conditions are suitable and in accordance with locally accepted horticultural practices, as judged by the Landscape Architect.

1. Soil moisture levels prior to planting shall be no less than seventy-five-percent (75%) of field capacity. The determination of adequate soil moisture for planting shall be in the sole judgment of the Landscape Architect, and their decision shall be final.

a. If the soil moisture level is found to be insufficient for planting installation, planting pits shall be filled with water and allowed to drain before commencing planting operations.

b. Any planting area that may become compacted in excess of eighty-five-percent (85%) relative compaction (due to construction operations or other activities during the Contract) shall be tilled and thoroughly cross-ripped to a minimum depth of nine-inches (9”) to alleviate the condition, taking care to avoid all existing subsurface utilities, drainage, etc.

c. Do not commence planting installation prior to acceptance of Section 329113 –Soil Preparation.

D. Contractor shall notify the Landscape Architect, in writing, on the anticipated commencement date and length of duration of the landscape installation.

E. Preparation of Planting Installation: Lay out individual Plant Material locations and areas for multiple plantings. Stake locations, outline areas, and gain the Landscape Architect’s acceptance prior to commencing physical planting installation.

F. At the discretion of the Landscape Architect, Contractor shall make field adjustments to the planting layout, as required, per the direction of the Landscape Architect. Layout changes made accordingly shall be performed at no additional cost to the Owner.

G. No more Plant Materials shall be distributed in the planting area on any day than can be installed and watered on that day. Plant Materials shall be planted and watered immediately after the removal of their containers, as applicable.

H. Contractor shall protect existing and new improvements and systems installed prior to planting installation. Maintain protection in place until completion of Work and Landscape Establishment Period.

I. Finish Grades for planting areas shall have been established (per Section 31 22 19 – Landscape Grading) prior to Work under this Section. Verify that grades are within one-inch plus or minus (1”+/-) of the required finish grade, and that all proper soil amendments and fertilizers have been furnished and installed accordingly as specified (per Section 329113 – Soil Preparation).

1. Maintain positive surface drainage of all planted areas throughout the duration of the Contract.

J. Pre-Planting: Where Plant Materials are to be pre-planted to permit site improvements to be installed around them, Contractor shall be responsible for the accurate layout and placement of those Plant Materials, as measured to their centerlines. Confirm designated pre-planting operations with Landscape Architect prior to commencing Work. Contractor shall also be responsible for the protection of pre-planted Plant Materials while other Work is taking place around them. Provide automated irrigation, as necessary, prior to installation and functioning of irrigation systems (per Section 32 84 00 – Irrigation Systems).

3.02 EXCAVATION FOR PLANT MATERIAL

A. General: Upon completion of applicable pre-planting soil preparation requirements indicated in Section 32 91 13 – Soil Preparation, excavate planting hole(s) for Plant Material with scarified vertical sides, with the bottom of the excavated hole slightly raised and compacted at the center to assist drainage and to minimize settlement of the Plant Material. Excavate holes according to the spacing alignment (i.e. hedge spacing, grid spacing, triangular spacing, etc.) and the on-center (O.C.) spacing intervals (i.e. 24” O.C. etc.) indicated on the Contract Drawings. Loosen any hard subsoil in the bottom of the excavation where evident, and remove all rocks greater than one-half-inch (1/2”) in diameter, trash, debris, etc. Retain the excavated soil for use as part of the Amended Planting Backfill Mixture (as indicated in Section 32 91 13 – Soil Preparation).

B. Planting areas that have not been excavated prior to planting.

1. Plug Plant Material:

a. Excavate at least four-inches (1”) wider than the perimeter of the plug, and deep enough to allow setting of the roots on a compacted layer of native planting soil, where the top of the plant’s root collar is one half-inch (1/2”) higher than finished grade or as further directed by the Landscape Architect.

2. Balled and Burlap Plant Material:

a. Excavate the planting hole to the width and depth indicated in the Contract Drawings. Depth of the planting hole includes the depth indicated for the compacted setting layer at the bottom of the excavation, where the top of the plant's root collar is two-inch (2") higher than finished grade or as further directed by the Landscape Architect:

b. Compacted Setting Layer: Provide a crown of a minimum six-inch (6") depth of native planting soil.

3. Container-Grown Plant Material:

a. Excavate the planting hole to the width and depth indicated on the Contract Drawings. Depth of the planting hole includes the depth indicated for the compacted setting layer at the bottom of the excavation, where the top of the plant's root collar is two-inch (2") higher than finished grade or as further directed by the Landscape Architect:

b. Compacted Setting Layer: Provide a crown of a minimum six-inch (6") depth of native planting soil.

4. Field Grown/Specimen Trees:

a. Excavate the planting hole to the width and depth indicated on the Contract Drawings. Depth of the planting hole includes the depth indicated for the compacted setting layer at the bottom of the excavation, where the top of the plant's root collar is three-inch (3") higher than finished grade or as further directed by the Landscape Architect:

b. Compacted Setting Layer: Provide a crown of a minimum six-inch (6") depth of native planting soil.

c. In areas where special subsurface drainage for planting is indicated, tie drainage pipes, as required, into the drain system.

d. Excavate planting hole at 3x the diameter of the rootball.

5. Permanent Seeding:

a. Treat seed area with an aquatic approved herbicide two (2) weeks prior to scarifying or applying topsoil.

b. Lightly scarify existing topsoil and place seed directly on existing soil.

c. When existing topsoil has been removed during grading operations, place a minimum of three-inches (3") of topsoil (Reference Section 32 91 13) to provide an acceptable seeding substrate.

C. Obstructions: Notify the Landscape Architect immediately if unexpected rock, debris, contaminants, obstructions, or other items that are detrimental to the healthy sustained growth of Plant Material is encountered in the excavation process.

1. Hardpan Layer: If encountered, drill six-inch (6") diameter holes into free-draining strata or to a depth of ten-feet (10'), whichever is less, and backfill with free-draining material.

D. Drainage: Notify the Landscape Architect if subsoil conditions show evidence of unexpected water seepage or retention in planting holes.

E. Time of Planting:

1. Evergreen material: Plant evergreen materials between September 1 and November 1 or in spring before new growth begins. If project requirements require planting at times, other than winter months, plants shall be sprayed with anti-desiccant prior to planting operations.

2. Deciduous material: Plant deciduous materials in a dormant condition. If deciduous trees are planted in-leaf, they shall be sprayed with an anti-desiccant prior to planting operation.

3.03 INSTALLATION

A. Plug Plant Material: Set Plug Plant Material plumb and in center of the excavated hole, with top of root structure set properly at the adjacent finish grade as indicated. Set Plug Plant Material in the proper spacing and/or alignment(s) as indicated on the Contract Documents, or as further directed at the Project Site by the Landscape Architect.

1. Thoroughly soak the roots in clean water for a minimum of two (2) hours but no more than four (4) hours to fully hydrate the root mass. Do not soak above the root crown.

2. Carefully place the Plant Material stock on the specified setting layer of compacted native soil, with the top of root mass set approximately one half-inch (1/2”) above the finished grade to allow for settlement of the Plant Material within the excavated planting hole. Provide an orientation of the Plant Material that is confirmed and acceptable by the Landscape Architect.

3. Prepare the Amended Planting Backfill Mixture: Amend each cubic yard (cu/yd) of native soil excavated from the planting hole by incorporating and thoroughly mixing/blending the following:

   a. ¼ yard of Bulk Composted Organic Soil Amendment Material (per Section 32 91 13 – Soil Preparation).

   b. ½ pound of Granular Soil Conditioning Material & Fertilizer (per Section 329113–Soil Preparation).

   c. Add Mycorrhizal Inoculum to the excavated native soil, (per Section 329113 – Soil Preparation), per the Manufacturer’s latest printed instructions.

      1) Pending the results of the Agronomic Soil Fertility Report, the Amended Planting Backfill Mixture may be modified accordingly to include additional soil amendments or fertilizers (gypsum, iron, potash, etc.) or the ratios as indicated in the Mixture indicated above may be modified.

         a) The cost of providing modifications to the Amended Planting Soil Backfill Mixture (as recommended through the Agronomic Soil Fertility Report and as directed by the Landscape Architect) shall be borne by the Contractor.

4. Backfilling the excavated planting hole:

   a. Place the Amended Planting Backfill Mixture around the Plant Material root mass in the excavated planting hole. Place the Mixture in six-inch (6”) lifts, tamping each lift accordingly to settle the Mixture and eliminate voids and air pockets.

   b. Maintain the Plant Material plumb while working the Mixture around the root mass. When the planting hole is approximately half-backfilled, water thoroughly before placing the remainder of the Mixture.

   c. Add the Fertilizer Tablets and other amendments, (per Section 329113 – Soil Preparation) as required, at the prescribed application rates (as indicated per Section 329113 – Soil Preparation) or if not indicated, per the Manufacturer’s latest printed instructions.

d. Place the final layers of the Amended Planting Backfill Mixture, tamping accordingly, to the top of the root mass.

e. Dish and tamp top of the Mixture to form a three-inch (3”) deep watering basin centered on the Plant Material’s trunk to the rim width of the planting hole.

f. Thoroughly mix together water and Plant Vitamin/Hormone Stimulant in application ratio as recommended by Stimulant Manufacture (per Section 329400 –Landscape Planting Accessories). Apply liquid matrix in sufficient quantity to thoroughly saturate the basin to settle the Mixture, and to eliminate voids and air pockets. Should any portions of the root mass be exposed, add additional Mixture as needed to thoroughly cover the root mass.

5. Mulching: Apply mulch evenly at 1” at all plug installation locations. Refer to Section 32 94 00) – Landscape Planting Accessories for type and requirements.

B. Balled and Burlapped Plant Material: Set the Balled and Burlapped Plant Material plumb and in center of the excavated hole, with top of the root ball raised above adjacent finish grade as indicated. Set Balled and Burlapped Plant Material in the proper spacing and/or alignment(s) as indicated on the Contract Documents, or as further directed at the Project Site by the Landscape Architect.

1. Carefully place the Balled and Burlapped Plant Material stock on the specified setting layer of compacted native soil, with the top of root ball set two-inch (2”) above the finished grade to allow for settlement of the Plant Material within the excavated planting hole. Provide the orientation of the Plant Material that is confirmed and accepted by the Landscape Architect. During the process of determining an acceptable orientation of the Plant Material, handle the Plant Material by its root ball; avoid handling the Plant Material by its trunk.

2. Once orientation is accepted, carefully remove the burlap and wire baskets from the tops of the root ball and partially from the sides, but do not remove from under the root ball. Do not damage the root ball or any part of the plant. Plant Material shall be rejected if the root ball is cracked or broken before or during the planting operation.

3. Prepare the Amended Planting Backfill Mixture: Amend each cubic yard (cu/yd) of native soil excavated from the planting hole by incorporating and thoroughly mixing/blending the following:

a. ¼ yard of Bulk Composted Organic Soil Amendment Material (per Section 32 91 13 – Soil Preparation).

b. ½ pound of Granular Soil Conditioning Material & Fertilizer (per Section 32 91 13–Soil Preparation).

c. Add Mycorrhizal Inoculum to the excavated native soil, (per Section 32 91 13 –Soil Preparation), per the Manufacturer’s latest printed instructions.

4. Backfilling the excavated planting hole:

a. Place the Amended Planting Backfill Mixture around the root ball in the excavated planting hole. Place the Mixture in six-inch (6”) lifts, tamping each lift accordingly to settle the Mixture and eliminate voids and air pockets.

b. Maintain the plant plumb while working the Mixture around the root ball. When the planting hole is approximately half-backfilled, water thoroughly before placing the remainder of the Mixture.

c. Add the Fertilizer Tablets and other amendments, (per Section 32 91 13 – Soil Preparation) as required, at the prescribed application rates indicated herein this Article or if not indicated, per the Manufacturer’s instructions.

d. Place the final layers of the Mixture, tamping accordingly, to the top of the root ball. Do not place the Mixture on top of the root ball. Pull soil away and exposed root flare. Ensure root flare is planted above finished grade.

e. Dish and tamp top of the Mixture to form a three-inch (3”) deep watering basin centered on the Plant Material’s trunk to the rim width of the planting hole. Do not cover the top of the root ball with the backfill mixture.

f. Thoroughly mix water and Plant Vitamin/Hormone Stimulant in application ratio as recommended by Stimulant Manufacture (per Section 32 94 00–Landscape Planting Accessories). Apply liquid matrix in sufficient quantity to thoroughly saturate the basin to settle the Mixture, and to eliminate voids and air pockets. Should any portions of the root mass be exposed, add additional Mixture as needed to thoroughly cover the root mass.

5. Mulching: Apply mulch in watering basins as indicated on the Contract Drawings. Refer to Section 32 94 00 – Landscape Planting Accessories for type and requirements.

6. Wrapping:

a. Inspect trees for injury to trunks, evidence of insect infestation, and improper pruning before wrapping.

b. Wrap trunks of all trees as directed spirally from bottom to top with specified tree wrap and secure in place.

c. Overlap 1/2 the width of the tree wrap strip and cover the trunk from the ground to the height of the second branch.

d. Secure tree wrap in place with twine wound spirally downward in opposite direction, tied around the tree in at least 3 places in addition to the top and bottom.

7. Staking/guying:

a. Stake/guy all trees immediately after each tree planting.

b. Stake all trees and all multi-trunk trees.

c. Flag or color all cables.

d. All work shall be acceptable to the Landscape Architect.

C. Container-Grown and Ball and Burlap Plant Material: Set Plant Material plumb and in the center of the excavated planting hole, with top of the root ball raised above adjacent finish grade as indicated. Set Plant Material in the proper spacing and/or alignment(s) as indicated on the Contract Documents, or as further directed at the Project Site by the Landscape Architect.

1. For plastic container stock (4” pot, 1-gallon, 5-gallon, 15-gallon, etc.), carefully remove the plant container prior to setting the plant in the excavated hole so as not to damage root ball. Tip container to horizontal position and shake carefully to remove Plant Material. Support root ball during installation to prevent cracking or shedding of soil.
2. Set the Plant Material stock on the specified setting layer of compacted native soil, with the top of root ball set one-inch (1”) above the finished grade to allow for settlement of the Plant Material within the excavated planting hole. Provide the orientation of the Plant Material that is confirmed and accepted by the Landscape Architect. During the process of determining an acceptable

orientation of the plant material, carefully handle the Plant Material by its container; avoid handling the Plant Material by its trunk.

a. Plant Material with a damaged root ball upon removal of the container, or if the root ball fails to thoroughly hold the soil as it is removed from the container, or if the plant is mishandled or damaged during planting operations, shall be rejected.

3. For Ball and Burlap stock, carefully set whole root ball of the Plant Material stock on the specified setting layer of compacted native soil, with the top of root ball set two-inch (2") above the finished grade to allow for settlement of the Plant Material within the excavated planting hole. Provide the orientation of the Plant Material that is confirmed and accepted by the Landscape Architect. During the process of determining an acceptable orientation, carefully handle the Plant Material by its basket; avoid handling the Plant Material by its trunk or branches. Once orientation is accepted, remove 1/3 of the wire basket so as not to damage the root ball or any part of the plant. Do not remove the bottom of the wire basket. Discard top 1/3, do not bend back or bury.

a. Plant Material with a damaged root ball upon placing/planting, or if the root ball fails to thoroughly hold the soil as it is planted, or if the plant is mishandled or damaged during planting operations, shall be rejected.

4. Prepare the Amended Planting Backfill Mixture: Amend each cubic yard (cu/yd) of native soil excavated from the planting hole by incorporating and thoroughly mixing/blending the following:

a. ¼ yard of Bulk Composted Organic Soil Amendment Material (per Section 32 91 13 – Soil Preparation).

b. ½ pound of Granular Soil Conditioning Material & Fertilizer (per Section 32 91 13– Soil Preparation).

c. Add Mycorrhizal Inoculum to the excavated native soil, (per Section 32 91 13 –Soil Preparation), per the Manufacturer's latest printed instructions.

1) Pending the results of the Agronomic Soil Fertility Report, the Amended Planting Backfill Mixture may be modified accordingly to include additional soil amendments or fertilizers (gypsum, iron, potash, etc.) or the ratios as indicated in the Mixture indicated above may be modified.

a) The cost of providing modifications to the Amended Planting Soil Backfill Mixture (as recommended through the Agronomic Soil Fertility Report and as directed by the Landscape Architect) shall be borne by the Contractor.

5. In areas where indicated on the Contract Drawings, install the Deep Watering Bubblers as part of the irrigation system.

6. Backfilling the excavated planting hole:

a. Place the Amended Planting Backfill Mixture around the root ball in the excavated planting hole. Place the Mixture in six-inch (6") lifts, tamping each lift accordingly to settle the Mixture and eliminate voids and air pockets. Foot tamp the backfill, as required.

b. Maintain the plant plumb while working the Mixture around the root ball. When the planting hole is approximately half-backfilled, water thoroughly before placing the remainder of the Mixture.

c. Add the Fertilizer Tablets and other amendments (per Section 32 91 13 – Soil Preparation) as required, at the prescribed application rates indicated herein this Article or if not indicated, per the Manufacturer's instructions.

d. Place the final layers of the Mixture, tamping accordingly, to the top of the root ball. Do not place the Mixture on top of the root ball.

e. Dish and tamp top of the Mixture to form a three-inch (3") deep watering basin centered on the Plant Material's trunk to the rim width of the planting hole. Do not cover the top of the root ball with the backfill mixture.

7. Mulching: Apply mulch in watering basins as indicated on the Contract Drawings. Refer to Section 32 94 00 – Landscape Planting Accessories for type and requirements.

8. Wrapping:

a. Inspect trees for injury to trunks, evidence of insect infestation, and improper pruning before wrapping.

b. Wrap trunks of all trees as directed spirally from bottom to top with specified tree wrap and secure in place.

c. Overlap 1/2 the width of the tree wrap strip and cover the trunk from the ground to the height of the second branch.

d. Secure tree wrap in place with twine wound spirally downward in opposite direction, tied around the tree in at least 3 places in addition to the top and bottom.

9. Staking/guying:

a. Stake/guy all trees immediately after each tree planting.

b. Stake all trees and all multi-trunk trees.

c. Flag or color all cables.

d. All work shall be acceptable to the Landscape Architect.

D. Native Wildflower and Grass Seed Material: Drill or hand apply seed per volumes specified within the Construction Documents. Apply native grass and wildflower seed after ground preparation is complete between September 15 and October 15 or February 15 and March 15. Landscape Architect shall be consulted prior to seeding to review preparation and installation.

1. Seed as follow to ensure complete coverage as noted:

a. Treat all seed areas with an aquatic approved herbicide when vegetation is present, two (2) prior to all seeding.

b. Fine grade areas that receive seed eliminate low areas that may hold water.

c. Provide 2 parts masonry sand to 1 part pure live seed (PLS). Granule Mycorrhizal shall also be included and may substitute the masonry sand.

d. Herbicide reapplication shall be required prior to broadcasting seed if visible vegetation is present.

e. Broadcast half the Native Grass and/or Wildflower Seeds evenly over the entire area prior to placement of compost at the rates indicated within the Construction Documents. Sow remaining seed in a perpendicular direction to the initial sowing prior to placement of compost.

f. Placement of one-half inch (1/2") organic compost by Landscape Contractor

g. Wildflower seed to be broadcast similar to the above and seed shall be allows to rest on top of the compost without pressing into the substrate. Do not cover the seed more than 1/16”.

h. Cover seed with a 100% wood fiber hydroseeding mulch

2. Jute netting or Biodegradable Erosion Control Blanket:

a. Install per plans and/or all areas that exceed 3:1 slopes using biodegradable stakes

3.04 PRUNING AND THINNING OF PLANT MATERIAL

A. Pruning/Thinning of Tree Canopy

1. At no time shall Plant Material be pruned, trimmed, thinned, shaped, or topped prior to delivery. Pruning, trimming, thinning, shaping, or topping of Plant Material shall be only conducted on the Project Site, and under the presence and direction of the Landscape Architect or approved Certified Arborist. Plant Material that has been pruned and delivered to the Project Site without prior approval by the Landscape Architect or an approved Certified Arborist will be rejected.

B. When directed by the Landscape Architect or an approved Certified Arborist, Contractor shall prune, thin, and shape plant material, according to standard horticultural practice, to preserve the natural character of the Plant Material.

1. Pruning and remedial work shall be done per ANSI A300.

2. Prune trees to retain required height and spread. Do not cut tree leaders; remove only injured or dead branches from trees.

3. Prune shrubs accordingly to retain natural character.

4. Provide pruning, cabling and bracing, irrigation, pest and disease control and other remedial treatments as recommended to assure the long-term health of the trees and existing vegetation, and the safety of persons and property.

5. Newly planted trees shall be pruned near the termination of the Landscape Establishment Period, per the direction of the Landscape Architect, as required.

3.05 CLEAN UP AND PROTECTION

A. During installation operations, keep Work area in an orderly and safe condition. Contractor shall remove trash caused from his Work on a weekly basis throughout the duration of the Work.

B. Protect landscaping from damage due to landscape operations, operations by other Contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

C. Upon completion of his Work under this Section, the Contractor shall remove rubbish, waste, debris, excess construction materials, surplus soil and other items resulting from construction operations and legally dispose of it off the Owner’s property.

D. Scars, ruts, or other marks in the ground caused by the Contractor’s Work shall be repaired.

E. Remove equipment and implements of service and leave the entire Project Site area in a neat, clean, and Owner-approved condition.

F. Labels: Remove all nursery-type labels, flags, and or identification markings from Plant Materials AS DIRECTED BY THE Landscape Architect.

3.06 MAINTENANCE

A. Maintain the trees, shrubs, groundcovers, perennials, native grasses until Final Completion of the entire project. Upon Final Completion, the Owner will assume maintenance as recommended by the written maintenance instructions submitted by the Landscape Contractor for Sodded areas only.

B. Maintenance shall include pruning, cultivating, weeding, watering, and application of appropriate insecticides and fungicides necessary to maintain plants free of insects and disease.

1. Re-set settled plants to proper grade and position. Restore planting saucer and adjacent material and remove dead material.

2. Tighten and repair guy wires and stakes as required.

3. Correct defective work as soon as possible after deficiencies become apparent and weather and season permit.

4. Deep-water trees, plants, groundcover, perennial and native grass beds within the first 24 hours of initial planting, and thereafter as required for healthy growth until final acceptance.

3.07 SUBSTANTIAL COMPLETION

A. An inspection of the trees, shrubs, groundcovers, perennials and native grasses will be made by the Landscape Architect upon request for Application of Substantial Completion by the Landscape Contractor. Provide notification of at least five (5) working days before requested inspection date.

3.08 FINAL COMPETITION

A. An inspection of the trees, shrubs and ground covers will be made by the Landscape Architect upon request for Final Completion by the Landscape Contractor.

END OF SECTION 32 93 00

**DIVISION 33 – UTILITIES**

**Section 33 01 30.72 – Cured-In-Place Pipe (CIPP)**

**PART 1 GENERAL**

**1.1 SECTION INCLUDES:**

A. These specifications include the requirements for the rehabilitation of sanitary sewer pipelines by the installation of Cured-In-Place Pipe (CIPP) within the existing, deteriorated pipe as shown on the plans included as part of these contract documents.

B. Pipe diameters listed in the specifications and/or on the plan drawings are assumed to be within tolerance of acceptable manufacturing dimensions at the time of production. Contractor shall satisfy himself to determine if there are any pipes with non-standard diameter dimensions and incorporate that condition into his bid.

C. The rehabilitation of pipelines shall be done by the installation of a resin-impregnated flexible tube which, when cured, shall be continuous and tight-fitting throughout the entire length of the original pipe. The CIPP shall extend the full length of the original pipe and provide a structurally sound, joint-less and water-tight new pipe within a pipe. The Contractor is responsible for proper, accurate and complete installation of the CIPP using the system selected by the Contractor.

D. Neither the CIPP system, nor its installation, shall cause adverse effects to any of the Owner's processes or facilities. The use of the product shall not result in the formation or production of any detrimental compounds or by-products at the wastewater treatment plant. The Contractor shall notify the Owner and identify any by-products produced as a result of the installation operations, test and monitor the levels, and comply with any and all local waste discharge requirements. The Contractor shall cleanup, restore existing surface conditions and structures, and repair any of the CIPP system determined to be defective. The Contractor shall conduct installation operations and schedule cleanup in a manner to cause the least possible obstruction and inconvenience to traffic, pedestrians, businesses, and property owners or tenants.

E. The prices submitted by the Contractor, shall include all costs of permits, labor, equipment and materials for the various bid items necessary for furnishing and installing, complete in place, CIPP in accordance with these specifications. All items of work not specifically mentioned herein which are required by the contractor to make the product perform as intended and deliver the final product as specified herein shall be included in the respective unit prices bid.

**1.2 RELATED SECTIONS**

A. Division 1 – General Requirements

B. Division 2 – Existing Conditions

C. Section 33 01 30.41 – Sewer Cleaning, Flushing and CCTV

**1.3 DESCRIPTION OF WORK AND PRODUCT DELIVERY**

A. The Contractor shall provide all materials, labor, equipment, and services necessary for sewers to be lined, liner installation, reconnection of service connections, all quality controls, provide samples for performance of required material tests, final television inspection, testing of lined pipe system and warranty work, all as specified herein.

B. The product furnished shall be a complete CIPP system including all materials, applicable equipment and installation procedures. All CIPP systems or multi-component products will be required to meet the submittal requirements as contained herein.

C. The CIPP shall be continuous and joint-less from manhole to manhole or access point to access point and shall be free of all defects that will affect the long-term life and operation of the pipe.

D. The CIPP shall fit sufficiently tight within the existing pipe so as to not leak at the manholes or through the wall of the installed pipe. If leakage occurs at the manholes the Contractor shall seal these areas to stop all leakage using a material compatible with the CIPP as directed by the Owner at the price bid therefore in the Proposal. If leakage occurs through the wall of the pipe the liner shall be repaired or removed as recommended by the CIPP manufacturer. Final approval of the liner installation will be based on a leak tight pipe.

E. The CIPP shall be designed for a life of 50 years or greater and an equal service life.

F. The CIPP shall be designed as a fully structural stand-alone pipe-within-a-pipe. Installed CIPP shall be a structurally designed pipe within a pipe, meet or exceed all contract specified physical properties, fitting tightly within the existing pipe all within the tolerances specified. The installed CIPP shall withstand all applicable surcharge loads (soil overburden, live loads, etc.) and external hydrostatic (groundwater) pressure, if present, for each specific installation location.

G. The installed CIPP shall have a long term (50 year) corrosion resistance to the typical chemicals found in domestic sewage and defined in the referenced and applicable ASTM Standards.

H. All existing and confirmed active service connections and any other service laterals to be reinstated as directed by the Owner shall be re-opened robotically or by hand in the case of man-entry size piping, to their original shape and to at least 95% of their original capacity. All over-cut service connections will be properly repaired to meet the requirements of these specifications.

I. All materials furnished, as part of this contract shall be marked with detailed product information, stored in a manner specified by the manufacturer and tested to the requirement of this contract.

J. Testing and warranty inspections shall be executed by the Contractor in the presence of the Owner / Engineer. Any defects found shall be repaired or replaced by the Contractor.

K. The Contractor shall furnish all samples for product testing as required in these specifications. The Contractor shall take possession of the samples for testing and shall maintain the chain of custody, deliver the samples to an approved laboratory and pay for all material and product testing performed under this contract.

**1.4 REFERENCE TO STANDARDS**

A. The following documents form a part of this specification to the extent stated herein and shall be the latest editions thereof. Where differences exist between codes and standards, the requirements of these specifications shall apply. All references to codes and standards shall be to the latest revised version.
1. ASTM - F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
2. ASTM - F1743 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pull in and inflate and Curing of a Resin-Impregnated Tube
3. ASTM - D543 Standard and Practice for Evaluating the Resistance of Plastics to Chemical Reagents
4. ASTM - D638 Standard Test Method for Tensile Properties of Plastics
5. ASTM - D790 Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials

6. ASTM - D792 Standard Test Methods for Density and Specific Gravity of Plastics by displacement.
7. ASTM - F2019 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured- in-Place Thermosetting Resin Pipe (CIPP)
8. ASTM - D2122 Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
9. ASTM - D2990 Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
10. ASTM - D3567 Standard Practice for Determining Dimensions of Fiberglass (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings
11. ASTM - D3681 Standard Test Method for Chemical Resistance of “Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pipe in a Deflected Condition
12. ASTM - D5813 Standard Specification for Cured-in Place Thermosetting Resin Sewer Pipe
13. ASTM – D618 Standard Practice for Conditioning Plastics for Testing

**1.5 PRODUCT, MANUFACTURER/INSTALLER QUALIFICATION REQUIREMENTS**

A. CIPP products and installers shall have successful long-term track records.

B. Acceptable Products and Installers shall meet all of the following criteria to be deemed Commercially Acceptable:
1. For a Product to be considered Commercially Proven, a minimum of 100,000 linear feet of successful wastewater collection system installations in the U.S. must be documented to the satisfaction of the Owner to assure commercial viability.
2. For an Installer to be considered as Commercially Proven, the Installer must satisfy all insurance, financial, and bonding requirements of the Owner, and must have had at least 5 (five) years active experience in the commercial installation. In addition, the Installer must have successfully installed at least 50,000 feet of the product bid with similar pipe sizes and lengths in wastewater collection systems. Acceptable documentation of these minimum installations must be submitted to the Owner.

**1.6 PERFORMANCE WORK STATEMENT (PWS) SUBMITTAL**

A. The Contractor shall submit, to the Owner and Engineer, a Performance Work Statement (PWS) before or at the pre-construction meeting, which clearly defines the CIPP product delivery in conformance with the requirements of these contract documents. PWS shall be reviewed and processed by Owner and Engineer prior to Contractor starting work. Unless otherwise directed by the Owner, the PWS shall at a minimum contain the following:

B. Clearly indicate that the CIPP will conform to the project requirements as outlined in the Description of Work and as delineated in these specifications.

C. Include a detailed installation plan describing all preparation work, cleaning operations, pre- CCTV inspections, temporary pumping plan, traffic control layout, installation procedure, method of curing (including heat up, hold and cool down data), continuous temperature monitoring, service reconnection, quality control, testing to be performed, laboratory to perform testing, final CCTV inspection, warrantees furnished and all else necessary and appropriate for a complete CIPP liner installation. A detailed installation schedule shall be prepared, submitted and conform to the requirements of this contract.

D. Contractor’s description of the proposed CIPP lining technology, including a detailed plan for identifying all active service connections, maintaining service during mainline installation to each home connected to the section of pipe being lined.

E. A description of the CIPP materials to be furnished for the project. Materials shall be fully detailed in the submittals and conform to these specifications and/or shall conform to the pre-approved product submission.

F. A list of the Contractor's proposed staffing for the Work. This list includes the lead personnel including the superintendent, the foreman and the lead crew personnel for the CCTV inspection, resin wet-out, the CIPP liner installation, liner curing and the robotic service reconnections. Each person shall have a minimum of three (3) years of total experience with the CIPP technology proposed for this contract and must have demonstrated competency and experience to perform the scope of work contained in this contract. The name and experience of each lead individual performing work on this contract shall be submitted with the PWS. Personnel replaced by the contractor, on this contract, shall have similar, verifiable experience as the personnel originally submitted for the project.

G. Engineering design calculations (handwritten, spreadsheets and/or computer generated), in accordance with the Appendix of ASTM F-1216, for each length of liner to be installed including the thickness of each proposed CIPP. Provide detailed calculations for each pipe segment, including the equations provided in ASTM F1216, along with any assumptions or other documentation. Pipe segments shall be numbered using the numbering system shown on the plans. These calculations shall be prepared and sealed by a licensed Professional Engineer in Missouri, including the date when signed and license expiration date. All calculations shall include data that conforms to the requirements of these specifications. Calculated liner thicknesses shall not be less than the minimum thicknesses provided in this specification. Include in summary table the minimum field provided liner thickness (i.e., based on the standard felt thicknesses) and minimum design thickness.

H. Engineer shall review all design thickness calculations provided as a part of the submittal process. If design calculations utilize physical properties greater than properties listed in these specifications, provide documentation to support use of the proposed physical properties. The physical properties included in the design calculations submitted become the minimum acceptable values when testing field samples.

I. Proposed manufacturers' technology data shall be submitted for all CIPP products and all associated technologies to be furnished.

J. Submittals shall include information on the cured-in-place pipe intended for installation and all tools and equipment required for a complete installation. The PWS shall identify which tools and equipment will be redundant on the job site in the event of equipment breakdown. All equipment, to be furnished for the project, including proposed back-up equipment, shall be clearly described. The Contractor shall outline the mitigation procedure to be implemented in the event of key equipment failure during the installation process, such as equipment reserved (on will-call) from local rental companies.

K. A detailed description of the Contractor's proposed procedures for removal of any existing blockages in the pipeline that may be encountered during the cleaning process.

L. A detailed description of the Contractor's procedures and alternatives for addressing any active leakage identified in the CCTV inspections performed prior to installing the liner.

M. A detailed public notification plan shall be prepared and submitted including detailed staged notification to residences affected by the CIPP installation. Public notification plan shall include project specific details and include a draft notification of pending work. A generic notification plan is not acceptable.

N. An odor control plan shall be submitted, by the contractor, that will ensure that project specific odors will be minimized at the project site and surrounding area.

O. Compensation for all work required for the submittal of the PWS shall be considered incidental to the work required.

## 1.7 PRODUCT SUBMITTALS

A. Fabric Tube – including the manufacturer and description of product components.

B. Flexible membrane (coating) material – including recommended repair (patching) procedure if applicable.

C. Raw Resin Data - including the manufacturer and description of product components.

D. Manufacturers' shipping, storage and handling recommendations for all components of the CIPP System.

E. All MSDS sheets for all materials to be furnished for the project.

F. Tube wet-out & cure method including:
   1. A complete description of the proposed wet-out procedure for the proposed technology.
   2. The Manufacturer's recommended cure method - for each diameter and thickness of CIPP liner to be installed. The PWS shall contain a detailed curing procedure describing the curing medium and the method of application.
   3. A complete description of the monitoring of cure temperature.

## 1.8 QUALITY CONTROL PLAN (QCP)

A. A detailed quality control plan (QCP) shall be submitted to the Engineer that fully represents and conforms to the requirements of these specifications. At a minimum, the QCP shall include the following:
   1. Compensation for all work required for the submittal of the QCP shall be considered incidental to the work required.
   2. A detailed discussion of the proposed quality controls to be performed by the Contractor.
   3. Defined responsibilities, of the Contractor's personnel, for assuring that all quality requirements, for this contract, are met. These shall be assigned, by the Contractor, to specific personnel.
   4. Proposed procedures for quality control, product sampling and testing shall be defined and submitted as part of the plan.
   5. Proposed methods for product performance controls, including method of and frequency of product sampling and testing both in raw material form and cured product form.
   6. A scheduled performance and product test result reviews between the Contractor, Engineer and the Owner at a regularly scheduled job meeting.
   7. Inspection forms and guidelines for quality control inspections shall be prepared in accordance with the standards specified in this contract and submitted with the QCP.

B. Confirmation that liner will be wet out in an indoor environmentally controlled manufacturing setting.

C. If liner will be wet out on site, provide detailed description of processes and procedures used to ensure the same level of quality is provided as wet out conditions in an indoor environment.

## 1.9 CIPP REPAIR/REPLACEMENT

A. If there is a need to repair or replace a defective CIPP, the Contractor shall outline specific repair or replacement procedures for potential defects that may occur in the installed CIPP. Repair/replacement procedures shall be as recommended by the CIPP system manufacturer and shall be submitted as part of the PWS.

B. Defects in the installed CIPP that will not affect the operation and long-term life of the product shall be identified and defined.

C. Repairable defects that may occur in the installed CIPP shall be specifically defined by the Contractor based on manufacturer's recommendations, including a detailed step-by-step repair procedure, resulting in a finished product meeting the requirements of these contract specifications.

D. Un-repairable defects that may occur to the CIPP shall be clearly defined by the Contractor based on the manufacturer's recommendations, including a recommended procedure for the removal and replacement of the CIPP.

E. Owner and Engineer shall be provided an opportunity to review and accept proposed defect repair process prior to Contractor initiating the repair.

**1.10 RECORD DRAWINGS**

A. Record drawings, pre-& post inspection videos on hard drives or other media acceptable to the Owner shall be submitted to the Engineer, by the Contractor within 2 weeks of final acceptance of said work or as specified by the Owner. Record drawings will include the identification of the work completed by the Contractor and shall be prepared on one set of Contract Drawings provided to the Contractor at the onset of the project.

B. Record drawings shall be kept on the project site at all times, shall include all necessary information as outlined in the PWS and shall be updated as the work is being completed, and shall be clearly legible.

C. Compensation for all work required for the submittal of Record Drawings shall be considered incidental to the work required.

**1.11 WARRANTY**

A. The materials used for the project shall be certified by the manufacturer for the specified purpose. The Contractor shall warrant the liner material and installation for a period of one (1) year from the date of Substantial Completion. During the Contractor warranty period, any defect which may materially affect the integrity, strength, function and/or operation of the pipe, shall be repaired at the Contractor's expense in accordance with procedures included in Section 1.9 CIPP Repair/Replacement and as recommended by the manufacturer.

B. On any work completed by the Contractor that is defective and/or has been repaired, the Contractor shall warrant this work for (1) year in addition to the warranty required by the contract, from the date of acceptance of said repair work.

C. After a pipe section has been lined and for a period of time up to one (1) year following Substantial Completion of the project, the Owner may inspect all or portions of the lined system. The specific locations will be selected at random by the Owner and will include all sizes of CIPP from this project. If it is found that any of the CIPP has developed abnormalities since the time of "Post Construction Television Inspection," the abnormalities shall be repaired and/or replaced as defined in Section 1.9 CIPP Repair/Replacement and as recommended by the manufacturer. If, after inspection of a portion of the lined system under the contract, defects are found, the Owner may televise all the CIPP installed on the contract. All verified defects shall be repaired and/or replaced by the Contractor and shall be performed in accordance with Section 1.9 CIPP Repair/Replacement and per the original specifications, all at no additional cost to the Owner.

**PART 2 PRODUCTS**

**2.1 MANUFACTURERS**

A. Acceptable Manufacturers include:
1. Applied Felts
2. CIPP Corporation
3. Inliner Technologies
4. Insituform Technologies USA, LLC
5. National Liner
6. Premier-Pipe USA
7. Saertex-multicom
8. Pipenology, LLC

## 2.2 MATERIALS

A. The CIPP System must meet the chemical resistance requirements of these contract documents.

B. All materials, shipped to the project site, shall be accompanied by test reports certifying that the material conforms to the ASTM standards listed herein. Materials shall be shipped, stored, and handled in a manner consistent with written recommendations of the CIPP system manufacturer to avoid damage. Damage includes, but is not limited to, gouging, abrasion, flattening, cutting, puncturing, or ultra-violet (UV) degradation. On site storage locations, shall be approved by the Owner. All damaged materials shall be promptly removed from the project site at the Contractor's expense and disposed of in accordance with all current applicable agency regulations.

## 2.3 FABRIC TUBE

A. The fabric tube shall consist of one or more layers of absorbent non-woven felt fabric, felt/fiberglass or fiberglass and meet the requirements of ASTM F1216, ASTM F1743, ASTM D5813 & ASTM F2019. The fabric tube shall be capable of absorbing and carrying resins, constructed to withstand installation pressures and curing temperatures and have sufficient strength to bridge missing pipe segments, and stretch to fit irregular pipe sections. The contractor shall submit certified information from the felt manufacturer on the nominal void volume in the felt fabric that will be filled with resin.

B. The wet-out fabric tube shall have a uniform thickness and excess resin distribution that when compressed at installation pressures will meet or exceed the design thickness after cure.

C. The fabric tube shall be manufactured to a size and length that when installed will tightly fit the internal circumference, meeting applicable ASTM standards or better, of the original pipe. Allowance shall be made for circumferential stretching during installation. The tube shall be properly sized to the diameter of the existing pipe and the length to be rehabilitated and be able to stretch to fit irregular pipe sections and negotiate bends. The Contractor shall determine the minimum tube length necessary to effectively span the designated run between manholes. The Contractor shall verify the lengths in the field prior to ordering and prior to impregnation of the tube with resin, to ensure that the tube will have sufficient length to extend the entire length of the run. The Contractor shall also measure the inside diameter of the existing pipelines in the field prior to ordering liner so that the liner can be installed in a tight-fitted condition.

D. The outside and/or inside layer of the fabric tube (before inversion/pull-in, as applicable) shall be coated with an impermeable, flexible membrane that will contain the resin and facilitate, if applicable, vacuum impregnation and monitoring of the resin saturation during the resin impregnation (wet out) procedure.

E. No material shall be included in the fabric tube that may cause de-lamination in the cured CIPP. No dry or unsaturated layers shall be acceptable upon visual inspection as evident by color contrast between the tube fabric and the activated resin containing a colorant.

F. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made. The hue of the color shall be dark enough to distinguish a contrast between the fully resin saturated felt fabric and dry or resin lean areas.

G. Seams in the fabric tube, if applicable, shall meet the requirements of ASTM D5813.

H. The outside of the fabric tube shall be marked every 5 feet with the name of the manufacturer or CIPP system, manufacturing lot and production footage.

I. The minimum length of the fabric tube shall be that deemed necessary by the installer to effectively span the distance from the starting manhole to the terminating manhole or access point, plus that amount required to run-in and run-out for the installation process.

J. The nominal fabric tube wall thickness shall be constructed, as a minimum, to the nearest 0.5 mm increment, rounded up from the design thickness for that section of installed CIPP. Wall thickness transitions, in 0.5 mm increments or greater as appropriate, may be fabricated into the fabric tube between installation entrance and exit access points. The quantity of resin used in the impregnation shall be sufficient to fill all the felt voids for the nominal felt thickness. Care shall be taken to ensure resin has filled both ends of the liner material that provides a true representative sample for post installation laboratory testing as outlined in Article 3.06.

K. Included with the fabric tube shall be a heat-cured, styrene impermeable polymer coating to eliminate styrene emissions and odors. Multi-layer coating shall contain polyamide conforming to ASTM F1216 and ASTM F1743. Liner may be welded or stitched. From a sample, all layers shall be tested for compression strength per ASTM D1777. From a sample, each weld shall be destructively tested per ASTM D5035.

## 2.4 RESIN

A. The resin shall be a corrosion resistant polyester or vinyl ester resin and catalyst system or epoxy and hardener system that, when properly cured within the tube composite, meets the requirements of ASTM F1216, ASTM F1743 or F2019, the physical properties herein, and those, which are to be utilized in the design of the CIPP for this project. The resin shall produce CIPP which will comply with or exceed the structural and chemical resistance requirements of this specification.

B. The resin to tube ratio, by volume, shall be furnished as recommended by the manufacturer.

## 2.5 STRUCTURAL REQUIREMENTS

A. The physical properties and characteristics of the finished liner will vary considerably, depending on the types and mixing proportions of the materials used, and the degree of cure executed. It shall be the responsibility of the Contractor to control these variables and to provide a CIPP system which meets or exceeds the minimum properties specified herein:

B. The CIPP shall be designed as per ASTM F1216 Appendixes. The CIPP design shall assume no bonding to the original pipe wall.

C. The Contractor’s design engineer shall set the long term (50 year extrapolated) Creep Retention Factor at 50% of the initial design flexural modulus as determined by ASTM D-790 test method. This value shall be used unless the Contractor submits long term test data (ASTM D2990) to substantiate a higher retention factor in the PWS.

D. The cured-in-place-pipe material (CIPP) shall, at a minimum, meet or exceed the structural properties, as listed in Part 2.6. Contractor's design engineer shall substantiate the physical properties used in the design of the CIPP in the PWS by including test data.

E. CIPP design submittal shall be processed by Engineer and returned to Contractor with all comments addressed prior to liner being ordered. Contractor ordering liner without all submittal comments addressed proceeds at his own risk.

## 2.6 MINIMUM STRUCTURAL PROPERTIES

| Property | Test Method | Cured Composite Per ASTM F1216 or ASTMF1743 | Cured Composite Per ASTM F2019 | Cured Composite Per Design |
|---|---|---|---|---|
| Flexural Modulus of Elasticity | ASTM D790 | 250,000 psi | Declared Value, but not less than 725,000 psi | Contractor Provided Value |
| Flexural Strength | ASTM D790 | 4,500 psi | Declared Value, but not less than 15,000 psi | Contractor Provided Value |

A. The required structural CIPP wall thickness shall be based, as a minimum, on the physical properties of the cured composite and per the design of the Professional Engineer hired by the Contractor (see Section 1.6.G) and in accordance with the Design Equations contained in the appendix of the ASTM standards, and the following design parameters:

| ASTM F1216 Standard Property | Design Condition |
|---|---|
| Pipe Condition | Fully Deteriorated |
| Design Safety Factor | 2.0 |
| Creep Retention Factor | 50% |
| Ovality | 5% |
| Constrained Soil Modulus | 1,000 psi |
| Groundwater Depth | Equal to greatest height of soil above top of pipe between manholes |
| Soil Depth | Equal to greatest height of soil depth above top of pipe between manholes as indicated on drawings |
| Live Load | 16,000 lbs. (HS-20 loading) |
| K – Enhancement Factor | 7.0 |
| v - Poisson's Ratio | 0.3 |
| Soil Load (assumed) | 120 lb./cu. Ft. |
| Minimum Service Life | 50 ears |

B. The Contractor shall submit, prior to installation of the lining materials, certification of compliance with these specifications. Certified material test results shall be included that confirm that all materials conform to these specifications. Materials not complying with these requirements will be rejected.

C. The design soil modulus may be adjusted based on data determined from detailed project soil testing results as provided by the Contractor. If Contractor chooses to perform detailed soil testing, it shall be at no additional expense to the Owner.

## 2.7 HYDROPHILIC END SEAL SLEEVE

A. Intent:

1. Provide a safe, efficient, cost-effective installation method of a hydrophilic pipe end sealing product called Insignia$^{TM}$ End Seal for the junction of a mail and a manhole. The Insignia$^{TM}$ End Seal shall provide a full-circle compression sealing product, shall be compatible with inverted CIPP liners and pull-in-place CIPP liners. The Insignia$^{TM}$ End Seal product shall be as provided by LMK Technologies or accepted equal, for manufactured pipe materials. Minimum service life shall be 50 years. End Seal shall comply with ASTM F3240.

B. Overview:

1. The hydrophilic end seal sleeve process shall provide a full-circle seal at the junction of a main and a manhole by using a tubular sleeve of hydrophilic material specifically tailored to provide the safest, efficient, cost-effective, watertight seal at the ends of a rehabilitated pipe. Hydrophilic rope or caulk is not acceptable.
2. The hydrophilic end seal sleeve shall provide a hydrophilic material that does not shift or move during installation of a rehabilitative pipe liner and a uniform seal and consistent wall thickness around the pipe end after installation of a pipe liner.
3. The hydrophilic end seal sleeve shall include a tubular sleeve constructed of a hydrophilic polymeric material, designed with a specified length and wall thickness to provide a compression seal to the end of a pipe at the manhole. A mechanical fastener band shall be provided with the tubular sleeve that is specifically designed to hold the tubular sleeve in place during installation of a pipe liner. The mechanical fastener may utilize a double- sided adhesive to ensure that neither the tubular sleeve nor the fastener shift during installation.
4. The hydrophilic end seal sleeve shall be placed within the pipe to be rehabilitated adjacent to the manhole. A mechanical fastener shall be placed against the inner wall of the tubular sleeve during installation, securing the tubular sleeve against the inner wall of the pipe. For sizes 18" and larger, anchor screws should also be installed to assist in holding the mechanical fastening band in place. After the mechanical fastener is secured in place, a liner is inserted through the tubular sleeve utilizing known installation methods. After the liner is set in place, the tubular sleeve will swell in the presence of water, creating a full-circle seal between the newly installed liner and the host pipe for the entire length of the end seal sleeve.

C. Material:

1. The hydrophilic end seal sleeve shall be designed to accommodate varying pipe diameters, manhole depths, junction configurations, and pipe liner products. The end seal sleeve shall be compatible with cured-in-place pipe, and different pipe liner installation and curing methods.
2. Tubular Sleeve: The member that creates the end seal is a hydrophilic neoprene rubber of approximately 50 Shore A durometer. The tubular sleeve shall have a uniform wall thickness of approximately 2 mm, a length of approximately 3.5 inches, and a diameter slightly less than the interior pipe diameter. The hydrophilic neoprene rubber shall have the following characteristics:

| Characteristic | Unit | Value | Test Method |
|---|---|---|---|
| **Shore A Hardness** | point | 50 +/- 5 | ASTMD2240 |
| **Tensile Strength** | psi | 1,177 | ASTMD412 |
| **Elongation at Break** | % | 523 | ASTMD412 |
| **Specific Gravity** | | 1.2 | ASTMD297 |
| **Swell Capacity in Water Contact** | % | 200 | GRCSC |

3. Two types of mechanical fasteners may be used with end seal sleeve:
    a. A shape-memory alloy that has been formed into a specific acute or other curvilinear configuration having an outer profile that is generally greater than the circumference of the pipe before insertion.
    b. A ratcheting retaining ring includes a strip of material having a total length generally greater than the pipe diameter. A ratcheting worm gear is attached to the strip and the strip is formed into a ring shape of variable diameter

4. Dual-sided Adhesive Tape: For some mechanical fasteners, a dual-sided adhesive tape may be used to affix the mechanical fastener to the tubular sleeve before installation within the pipe. For sizes 18" and larger, anchor screws shall also be installed to assist in holding the mechanical fastening band in place.

D. Installation: install end seal sleeve in accordance with all manufacturer instructions.

## 2.8 SEALING BRICK SEWERS

A. For sewers constructed of brick, a cementitious water stop material shall be applied to the first 24-inches of the brick sewer surface to create a smooth surface on which to install the hydrophilic end seal sleeve, prior to installing the liner. Cementitious water stop material shall be Hyperform by Quadex or approved equal.

## 2.9 OTHER HYDROPHILIC MATERIALS

A. When conditions dictate a hydrophilic end seal sleeve is not appropriate to install in the host pipe to eliminate the flow of water in the annular space, such as non-circular pipe, other hydrophilic materials may be utilized. Materials submitted for the Engineer's review shall react freely with water in a wide range of proportions to form a strong film, gel or foam according to the mix design requirements of the product. Other hydrophilic material shall be AV-202 Multigrout by Avanti or Engineer approved product.

## 2.10 CONTINUOUS TEMPERATURE MONITORING

A. Contractor shall continuously monitor the cure cycle of the CIPP.
    1. It shall be a minimum requirement that the entire cure cycle (heat-up/cool-down) for pipe diameters 18 inches and greater shall be monitored by a system that will monitor the liner cure incrementally every 18 inches or less to verify that an exothermic reaction has occurred and that a full cure has taken place along the entire length of the liner. The cure information must be taken from the bottom third of the pipe liner. Cure parameter information shall be provided by the resin manufacturer.
    2. Owner shall receive a deliverable in the form of a visual graphic "waterfall" representation of the entire cure process as it relates to time, temperature and footage. For quality assurance purposes, the system shall have the ability to be remotely viewed "live" by the Engineer/Owner (at a minimum, through equipment used on site by the Contractor). Data collected shall be provided to the Owner/Engineer in both an Excel spreadsheet and read-only graphical viewer formats.
    3. Systems that just measure at each end or at wider intervals than every 18" will not be allowed. Data collected shall be provided to the Engineer and Owner at the same time as the post-lining inspection videos.
    4. Continuous monitoring shall be accomplished using Veri-Cure, or approved equal.

## PART 3 EXECUTION

### 3.1 CONSTRUCTION REQUIREMENTS

A. Includes preparation, cleaning, inspection, size verification, sewage by-passing and public notification. Contractor shall measure the inside diameter of all pipes to be lined on this project at the upstream and downstream locations and where there are transitions. Contractor shall notify the Owner and Engineer if non-standard pipe diameters are measured. Changes of +/- 1-inch in pipe diameters shall be considered incidental to the work with no additional compensation. Internal pipe dimensions shall be confirmed by Contractor prior to ordering the liner.

B. The Contractor shall clean the interior of the existing host pipe prior to installation of the CIPP liner. All debris and obstructions, that will affect the installation and the final CIPP product delivery to the Owner, shall be removed and disposed.

C. The CIPP liner shall be constructed of materials and methods, that when installed, shall provide a jointless and continuous structurally sound CIPP able to withstand all imposed static and dynamic loads for 50 years or more.

D. The Contractor may, under the direction of the Owner, utilize any of the existing manholes in the project area as installation access points. If Contractor's work and/or equipment is located in a public right-of-way, they shall furnish, install and maintain traffic devices in accordance with the Manual of Uniform Traffic Control Devices (MUTCD) and the details provided in the specifications and drawings.

E. Public Notification– The Contractor shall make every effort to maintain sewer service usage throughout the duration of the project. A public notification program shall be implemented and shall as a minimum, require the Contractor to be responsible for contacting each municipality, home or business in the vicinity of the sewer lining and informing them of work to be conducted, and when the sewer will be off-line. The Contractor shall also provide written notice to be delivered to each municipality, home or business the day prior to the beginning of work being conducted on the section, and a local telephone number of the Contractor they can call to discuss the project or any potential problems. **Contractor's notification shall include wording and graphics emphasizing the importance of ensuring plumbing traps are filled with water and to minimize customer water usage during the curing process.** If CIPP installation is delayed by weather after initial distribution of public notification, Contractor shall distribute notices again as described in the PWS.

F. By-passing Existing Sewage Flows - The Contractor shall provide for the flow of existing mainline and service connection effluent around the section or sections of pipe designated for CIPP installation. Service connection effluent may be plugged only after proper notification to the affected residence. Installation of the liner shall not begin until the Contractor has installed the required plugs, or a sewage by-pass system and all pumping facilities have been installed and tested under full operating conditions including the bypass of mainline flows, local sewer flows and sewer service connection flows (e.g., pipe-to-pipe and pipe-to-manhole connections). Once the lining process has begun, existing sewage flows shall be maintained, until the resin/felt tube composite is fully cured, cooled down, televising completed and the CIPP ends finished. The Contractor shall coordinate sewer bypass and flow interruptions with the Owner at least 14 days in advance and with the property owners and businesses at least 2 business day in advance.

G. Contractor shall perform pre-lining video inspections of the pipelines. Only PACP certified personnel trained in locating breaks, obstacles and service connections by closed circuit television shall perform the inspection. The Contractor shall provide the Owner and Engineer a copy of the pre-lining video and suitable log, and/or in digital format for review prior to installation of the CIPP and for later reference by the Owner.

H. Line Obstructions - It shall be the responsibility of the Contractor to clear the line of obstructions that will interfere with the installation and long-term performance of the CIPP. If pre-installation inspection reveals an obstruction, misalignment, broken or collapsed section or sag that was not identified as part of the original scope of work and will prohibit proper installation of the CIPP, the Contractor shall notify the Owner and Engineer immediately to address the problem(s). Removal of any previously unknown obstructions shall be considered as a changed condition. The cost of removal of obstructions that appeared on pre-bid video documentation and made available to the Contractor, prior to the bid opening, shall be included in the unit price bid item.

I. The Contractor shall be responsible for confirming the locations of all sewer service connections prior to installing and curing the CIPP. Sewer service connections that are visibly capped shall not be reinstated. In the event the status of a service connection cannot be adequately defined, the Owner will make the final decision as to the status, prior to installation and curing of the liner.
Only service connections deemed “active” shall be reopened by the Contractor.

J. Contractor shall coordinate with the local water utility to obtain water for operations.

L. Contractor shall be responsible for proposing, documenting and implementing a solution to address active leakage in the sewer prior to installing liner. Owner and Engineer shall concur with the solution. Proposed solution shall be one that minimizes the potential for resin wash-out and/or creating weak spots in the liner.

M. Contractor shall ensure all labor, equipment, materials and technology is in place and ready to be engaged for the CIPP installation. This includes cure temperature monitoring equipment.

## 3.2 INSTALLATION OF LINER

A. The CIPP Liner shall be installed and cured in the host pipe per the manufacturer’s specifications as described and submitted in the PWS.

B. CIPP installation shall be in accordance with the applicable ASTM standards with the following modification:
   1. The wet-out tube shall be positioned in the pipeline using the method specified by the manufacturer. Care should be exercised not to damage the tube as a result of installation. The tube should be pulled-in or inverted through an existing manhole or approved access point and fully extend to the next designated manhole or termination point.

C. Prior to installation and as recommended by the manufacturer remote temperature gauges or sensors shall be placed inside the host pipe to monitor the temperatures during the cure cycle. Liner and/or host pipe interface temperature shall be monitored and logged during curing of the liner.

D. To monitor the temperature of the liner wall and to verify correct curing and where specified by the contract documents, temperature sensors can be placed between the host pipe and the liner in the bottom of the host pipe (invert) throughout its length to monitor the temperature on the outside of the liner during the curing process. The temperature sensors can be placed at intervals as recommended by the sensor manufacturer. Additional sensors can be placed where significant heat sinks are likely or anticipated. The sensors, if installed, should be monitored by a computer using a tamper proof data base that is capable of recording temperatures at the interface of the liner and the host pipe.

E. Curing shall be accomplished by utilizing the appropriate medium in accordance with the manufacturer’s recommended cure schedule. The curing source or input and output temperatures shall be monitored and logged during the cure cycles. The manufacturer’s recommended cure method & schedule shall be used for each line segment installed, and the liner wall thickness and the existing ground conditions with regard to temperature, moisture level, and thermal conductivity of soil, per ASTM as applicable, shall be taken into account by the Contractor.

F. For heat cured liners, if any temperature sensor or multiple sensors do not reach the temperature as specified by the manufacturer to achieve proper curing or cooling, the installer can make necessary adjustments to comply with the manufacturer's recommendations. The system computer should have an output report that specifically identifies each installed sensor station in the length of pipe, indicates the maximum temperature achieved and the sustained temperature time. Each sensor should record both the maximum temperature and the minimum cool down temperature and comply with the manufacturer's recommendations. The cure procedure shall be in accordance with the manufacturers recommendation as included in the PWS submission by the contractor. Copies of 'cook sheets' shall be submitted to Owner and Engineer with post installation CCTV data.

G. For UV Cured Liners, all light train sensor readings, recorded by the tamper proof computer, shall provide output documenting the cure along the entire length of the installed liner. The cure procedure shall be in accordance with the manufacturer's recommendation as included in the PWS submission by the contractor.

H. UV light curing of glass fiber (fiberglass) tubing shall adhere to the following:
1. The approved system shall utilize an outer and inner film to ensure that the liner remains intact during the insertion process and to protect the resin at all times during the installation and curing process from water and debris contamination, and resin migration.
2. A constant tension winch should be used to pull the glass fiber liner into position in the pipe. The liner shall have a lateral fiberglass reinforcement band which runs the entire length of the liner ensuring that the pulling force is transferred to the band and not the fiberglass liner. Once inserted, end plugs shall be used to cap each end of the glass fiber liner to prepare for pressurizing the liner. The end plugs should be secured with straps to prevent them from being expelled due to pressure. Liner restraints should be used in manholes.
3. A slip sheet shall be installed on the bottom one third to one half of the pipe prior to liner insertion, for the purpose of protecting the liner during insertion and reduce the drag, or as recommend by the liner manufacturer.
4. The glass fiber liner shall be cured with UV light sources at a constant inner pressure. When inserting the curing equipment in the liner, care should be taken to not damage the inner film material.
5. The UV light sources should be assembled according to the manufacturer's specifications for the liner diameter. For the liner to achieve the required water tightness and specified mechanical properties, the following parameters shall be controlled during the entire curing process, giving the Engineer a record of the curing parameters over every segment of the entire length of the liner. This demonstrates that the entire liner is cured properly.
   The recording will include:
   a. Curing Speed
   b. Light speed
   c. Light source working and wattage
   d. Inner air pressure
   e. Curing temperature
   f. Date and Time
   g. Length of liner

   This shall be accomplished using a computer and data base that are tamper proof. During the curing process, infrared sensors will be used to record curing data that will be submitted to the Owner/Engineer with a post CCTV inspection on DVD or acceptable digital media.

6. The optimal curing speed, or travel speed of the energized UV light sources, is determined for each length of liner based on liner diameter, liner thickness, and exothermic reaction temperature.
7. The inner film material should be removed and discarded after curing to provide optimal quality of the final product.

## 3.3 COOL DOWN

A. The Contractor shall cool the CIPP in accordance with the approved CIPP manufacturer's recommendations as described and outlined in the PWS.

B. Temperatures and curing data shall be monitored and recorded, by the Contractor, throughout the installation process to ensure that each phase of the process is achieved as approved in accordance with the CIPP System manufacturer's recommendations.

C. Water used in the curing process shall be discharged to the nearest sanitary sewer or hauled to the nearest wastewater treatment plant. **No** water used in the curing process shall be discharged to storm sewer or receiving waters.

## 3.4 FINISH

A. The installed CIPP shall be continuous over the entire length of a sewer line section and be free from visual defects such as foreign inclusions, dry spots, pinholes, major wrinkles and de-lamination. The CIPP shall be impervious and free of any leakage from the pipe to the surrounding ground or from the ground to inside the lined pipe.

B. Any defect, which will or could affect the structural integrity or strength of the linings, shall be repaired at the Contractor's expense, in accordance with the procedures submitted under Section 1.09 CIPP Repair/Replacement.

C. The beginning and end of the CIPP shall be sealed to the existing host pipe. The sealing material shall be compatible with the pipe end and shall provide a watertight seal.

D. If any of the service connections leak water between the host pipe and the installed liner, the connection to mainline interface shall be sealed to provide a watertight connection.

E. If the wall of the CIPP leaks, it shall be repaired or removed and replaced with a watertight pipe as recommended by the manufacture of the CIPP system.

F. Compensation shall be at the actual length of cured-in-place pipe installed. The length shall be measured from center of manhole to center of manhole. The unit price per linear foot installed shall include all materials, labor, equipment and supplies necessary for the complete CIPP liner installation. Compensation for pipe sealing at the manhole/wall interface, shall be included in the unit price bid.

## 3.5 MANHOLE CONNECTIONS AND RECONNECTIONS OF EXISTING SERVICES

A. A hydrophilic seal compatible with the installed CIPP shall be applied at manhole/wall interface in accordance with the CIPP System manufacturer's recommendations.

B. Existing services shall be internally or externally reconnected unless indicated otherwise in the contract documents

C. Reconnections of existing services shall be made after the CIPP has been installed, fully cured, and cooled down. It is the CONTRACTOR'S responsibility to make sure that all active service connections, as confirmed by the Owner, are reconnected.

D. External reconnections, where necessary, are to be made with a tee fitting in accordance with CIPP System manufacturer's recommendations. Saddle connections shall be seated and sealed to the new CIPP using grout or resin compatible with the CIPP.

E. A CCTV camera and remote cutting tool shall be used for internal reconnections. The machined opening shall be at least 95 percent of the service connection opening and the bottom of both openings must match. The opening shall not be more than 100 percent of the service connection opening. The edges of the opening shall not have pipe fragments or liner fragments, which may obstruct flow or snag debris. In all cases the invert of the sewer connection shall be cut flush with the invert entering the mainline lining. Materials protruding from the service connection opening shall be brushed back into the service.

F. In the event that service reinstatements result in openings that are greater than 100 percent of the service connection opening, the Contractor shall install a CIPP type repair, sufficiently in size to completely cover the over-cut service connection. No additional compensation will be paid for the repair of over-cut service connections.

G. Coupons of pipe material resulting from service tap cutting shall be collected at the next manhole downstream of the pipe rehabilitation operation prior to leaving the site. Coupons may not be allowed to pass through the system.

H. Compensation shall be at the actual number of services re-connected. The unit price bid per service line re-connected shall include all materials, labor, equipment and supplies necessary to complete the work as required in these specifications.

I. Where CIPP liner has been installed through a manhole(s), the top of the liner shall be carefully cut and removed after curing and cool down so the top of the liner material is the same as the channel inside the manhole, restoring access to the sewer main.

### 3.6 TESTING OF INSTALLED CIPP

A. The physical properties of the installed CIPP shall be verified through field sampling and laboratory testing. All materials for testing shall be furnished by the Contractor to the Laboratory for testing. All materials testing shall be performed at the Contractor's expense, by an independent third-party laboratory selected by the Owner as recommended by the CIPP manufacturer. All tests shall be in accordance with applicable ASTM test methods to confirm compliance with the requirements specified in these contract documents.

B. The Contractor shall provide samples for testing for review by the Owner and Engineer from the actual installed CIPP liner. Samples shall be provided, at a minimum, from one location per segment (or shot) of CIPP installed for each pipe diameter and thickness using a properly restrained sample and heat sink. Samples shall be of sufficient length to take the minimum eight measurements at evenly spaced intervals around the circumference of the sample. For pipe size 18-inch diameter or less, the sample shall be cut from a section of cured CIPP that has been inverted or pulled through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags. For pipes greater than 18-inches in diameter the sample shall be fabricated from material taken from the tube and the resin/catalyst system and cured in a clamped mold placed in the downtube when heated water is used and in the silencer when steam is used. The Opening produced from the sample shall be repaired in accordance with manufacturers recommended procedures. Properties to be tested include flexural modules of elasticity, flexural strength and liner thickness. All curing, cutting and identification of samples will be witnessed by the Engineer and transmitted by the Contractor to the testing laboratory.

C. The laboratory results shall identify the test sample location as referenced to the nearest manhole number. Final payment for the project shall be withheld pending receipt and approval of the test results. If properties tested do not meet the minimum physical and thickness requirements, the CIPP shall be repaired or replaced by the Contractor unless the actual physical properties and the thickness of the sample tested meet the design requirements as required in the contract.

D. Chemical resistance - The CIPP system installed shall meet the chemical resistance requirements of ASTM D5813. CIPP samples tested shall be of fabric tube and the specific resin proposed for actual construction. It is required that CIPP samples without plastic coating meet these chemical testing requirements. A certification may be submitted, by the Contractor, from the manufacturer, verifying that the chemical resistance of the CIPP meets the contract requirements.

E. Hydraulic Capacity - Overall, the hydraulic capacity shall be maintained as large as possible. The installed CIPP shall at a minimum be equal to the full flow capacity of the original pipe before rehabilitation. In those cases, where full capacity cannot be achieved after liner installation, the Contractor shall submit a request to waive this requirement, together with the reasons for the waiver request. Calculated capacities may be derived using a commonly accepted roughness coefficient for the existing pipe material taking into consideration its age and condition.

F. The installed CIPP thickness shall be measured for each line section installed. If the CIPP thickness does not meet that minimum specified in the contract and submitted as the approved design by the Contractor, then the liner shall be repaired or removed unless the tested physical properties and the thickness of the sample tested meet the design requirements as required in the contract. The liner thickness shall have tolerance of minus 5% to plus 10% from the installed thickness. The installed liner thickness shall be greater than or equal to the minimum design thickness as shown in the Contractor’s design calculations. In man-entry size piping the Contractor shall remove a minimum of one sample or one sample every line section of installed CIPP, not meeting the specified design thickness, to be used to check the liner thickness. The samples shall be taken by core drilling 2-inch diameter test plugs from the 12:00 o’clock position, at random locations selected by the Owner. As an alternative the Contractor may use industry proven, non-destructive methods for confirming the thickness of the installed CIPP.

G. All costs, to the Contractor, associated with providing cured CIPP samples for testing shall be included in the unit price bid. Payment for all testing by a laboratory will be paid for, by the Contractor.

**3.7 FINAL ACCEPTANCE**

A. All CIPP sample testing and repairs to the installed CIPP as applicable, shall be completed, before final acceptance, meeting the requirements of these specifications and documented in written form.

B. The Contractor shall perform a detailed closed-circuit television inspection in accordance with ASTM standards and these specifications (33 01 30.41), in the presence of the Owner and Engineer after installation of the CIPP liner and reconnection of the service sewers. A radial view (pan and tilt) TV camera shall be used. The finished liner shall be continuous over the entire length of the installation and shall be free of significant visual defects, damage, deflection, holes, leaks and other defects. Unedited digital documentation of the inspection shall be provided to the Engineer on hard drives or other acceptable digital media within ten (10) working days of the liner installation. Two sets of videos and reports shall be submitted to the Engineer. Payment for CIPP installed is eligible for payment only when the inspection reports, temperature monitoring reports and video files have been submitted. The data shall note the inspection date, location of all reconnected service sewers, debris, as well as any other defects in the liner, including, but not limited to, gouges, cracks, bumps, or bulges. If post installation inspection documentation is not submitted within ten (10) working days of the liner installation, the Owner may at its discretion suspend any further installation of CIPP until the post-installation documentation is submitted. As a result of this suspension, no additional working days will be added to the contract, nor will any adjustment be made for increase in cost. Immediately prior to conducting the closed-circuit television inspection, the Contractor shall thoroughly clean the newly installed liner removing all debris and build-up that may have accumulated from installation and reopening of service connections, at no additional cost to the Owner. Debris shall be collected at the downstream manhole and removed.

C. Bypass pumping or plugging from the upstream manhole shall be utilized to minimize sewage from entering the line during the inspection. In the case of bellies in the line, the pipe shall be cleared of any standing water to provide continuous visibility during the inspection.

D. Where leakage is observed through the wall of the pipe, the contractor shall institute additional testing including but not limited to air testing, hydraulic testing, localized testing and any other testing that will verify that the leakage rate of the installed CIPP does not exceed acceptable tolerances specified in the contract. As an alternative to further leakage testing, the Contractor may choose to repair any observed leaks.

**3.8 ANNIVERSARY INSPECTION (Optional – Choose One or None)**

A. Contractor shall perform an anniversary inspection of the installed CIPP prior to the expiration of the one-year guarantee of improvements. Contractor shall contact the Owner / Engineer at least 30 calendar days in advance of the end of the guarantee period to schedule and complete the anniversary CCTV inspection. All CIPP defects identified shall be corrected by the Contractor at no cost to the Owner. Contractor shall prepare a schedule to correct the defects and submit to Owner in advance of performing the corrective work.

END OF SECTION 33 01 30.72

## SECTION 33 05 13 SEWER MANHOLES, FRAMES, AND COVERS

## PART 1 - GENERAL

### 1.1 SUMMARY

### 1.2 Section Includes

1. Monolithic concrete, modular precast concrete, masonry, and precast polyethylene manhole assemblies.

### 1.3 Related Sections

1. Section 31 23 16 - Excavation
2. Section 33 31 11 - Sanitary Sewage Systems
3. Section 33 40 00 - Storm Drainage Utilities

### 1.4 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by the basic designation only.

B. ASTM International (ASTM)
1. ASTM A48 - Gray Iron Castings.
2. ASTM C55 - Concrete Building Brick.
3. ASTM C478 - Precast Reinforced Concrete Manhole Sections.
4. ASTM C923 - Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes.
5. ASTM D1248 - Polyethylene Plastics Molding and Extrusion Materials.
6. ASTM D2412 - Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

C. International Masonry Industry All-Weather Council (IMIAC)
1. Recommended Practices and Guide Specification for Cold Weather Masonry Construction.

D. Missouri Standard Specifications for Highway Construction, latest edition.

E. Missouri Standard Plans for Highway Construction, latest edition.

### 1.5 SUBMITTALS

A. Shop Drawings: Indicate reference to Construction Drawings of manhole locations, elevations, piping with sizes, locations, and elevations of penetrations.

## PART 2 - PRODUCTS

### 2.1 MANHOLES

A. Cast-In-Place Concrete: Nonreinforced cast in place concrete barrel.
1. Concrete: 3500 psi concrete conforming to Section 03300.
2. Forms: Steel sheet accurately shaped and fabricated of sufficient strength to form dense watertight walls to true dimensions.

B. Precast Concrete: Reinforced precast concrete barrel.
1. Manhole sections conforming to ASTM C478 with gaskets in accordance with ASTM C923 or Section 1033 of the Missouri Standard Specifications for Highway Construction, latest Edition.
2. Construct manholes of precast concrete sections as required by Construction Drawings to size, shape, and depth indicated.

C. Concrete Brick: ASTM C55, Grade N Type I-moisture controlled, normal weight, of same grade, type and weight as block units, nominal modular size of 3 5/8-inches x 7 5/8-inches x 2 1/4-inches.

D. Precast Polyethylene:
1. Manufacturer: Advanced Drainage Systems (ADS) or approved equal.
2. Precast polyethylene in accordance with ASTM D1248. Nominal cylinder internal diameter shall be 48-inches and shall be designed to accept concrete filled polyethylene manhole lids and standard cast iron frames with lid or grate.
3. Manholes shall have compressive strength that meets ASTM D2412 standards.

E. Mortar and Grout: Mortar for finishing and sealing shall be Class "C". Honeycombing less than 2-inches deep shall be repaired using Class "D" mortar.

F. Brick Transition Reinforcement: Formed steel 8-gauge wire with galvanized finish.

G. Configuration:
1. Barrel Construction: Concentric with eccentric cone top section.
2. Shape: Cylindrical.
3. Clear Inside Dimensions: 48-inches diameter minimum or as indicated on Construction Drawings.
4. Design Depth: As indicated on Construction Drawings.
5. Clear Lid Opening: 22-inches minimum.
6. Pipe Entry: Provide openings as indicated on Construction Drawings.
7. Main and Lateral Pipes: Neatly cut off main and lateral pipes flush with inside of manhole or inlet where they enter structure walls. Point up irregularities and rough edges with nonshrinking grout.

H. Inverts: Shape inverts for smooth flow across structure floor as indicated on Construction Drawings. Use concrete and mortar to obtain proper grade and contour. Finish surface with fine textured wood float.

## 2.2 COMPONENTS

A. Lid and Frame:
1. Manufacturer: Neenah Foundry Company, East Jordan Iron Works, or approved equal.
2. ASTM A48, Class 30B heavy duty cast iron construction, machined flat bearing surface.
3. Removable lid, closed or open as indicated on Construction Drawings, sealing gasket.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify items specified by other Sections are properly sized and located.

B. Verify that built-in items are in proper location and ready for roughing into work.

C. Verify that the excavation for manholes is correct.

## 3.2 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves as indicated on Construction Drawings.

## 3.3 PRECAST MANHOLE CONSTRUCTION

A. Place base pad to proper elevation and location and trowel top surface level for placement of manhole barrel.

B. Place manhole barrel plumb and level to correct elevations and anchor to base pad.

1. After completion of slab foundation, lower first joint of manhole barrel into position, grooved end first, and set level and plumb on concrete base. Align and adjust to proper grade prior to placing and forming invert. Pour invert immediately after setting of first section of manhole barrel.
2. Prior to setting subsequent manhole barrel sections, apply primer to tongue and groove ends and allow to set in accordance with manufacturer's recommendations. Place "Ram-nek", or equivalent, plastic rope on tongue end. Lower next section into position, and remove excess material from interior of structure. Add additional material on exterior of joint, if necessary, for completely watertight joint.

C. Set cover frames and lids level without tipping, to correct elevations. Utilize pre-cast rings or brick and mortar to achieve final rim elevation. Maximum limit, 4 courses.

## 3.4 CAST-IN-PLACE MANHOLE CONSTRUCTION

A. Cast-in-place concrete shall conform to the applicable requirements of concrete in Division 3. Utilize steel forms.

B. Place base pad to proper elevation and location and pour monolithically with invert. Base shall support pipe to first joint.

C. Deposit concrete in evenly distributed layers of about 18 inches, with each layer vibrated to bond to preceding layer.

D. Place gasket between all joints and paint exterior of manhole within 5' of the joint with mastic waterproofing.

E. Place precast concrete cone.

F. Set section cover frames and lids level without tipping, to correct elevations. Utilize pre-cast rings or brick and mortar to achieve final rim elevation. Maximum limit, 4 courses.

## 3.5 MASONRY MANHOLE CONSTRUCTION

A. Maintain masonry courses to uniform dimension. Form vertical and horizontal joints of uniform thickness.

B. Lay masonry units in running bond. Course 3 brick units and 3 mortar joints to equal 8 inches.

C. Form flush mortar joints

D. Lay masonry units in full bed of mortar, with full head joints, uniformly jointed with other work.

E. Install joint reinforcement 16 inches on center

F. Place joint reinforcement in first and second horizontal joints above base pad and below lid frame opening

G. As work progresses, build in fabricated metal items

H. Cut and fit masonry for pipes as specified herein

I. Set cover frames and covers level to correct elevations without tipping.

**END OF DOCUMENT 33 51 11**

**Section 33 10 00 – Water Utilities**

**PART 1 - GENERAL**

**1.1 SUMMARY**

A. Section Includes

1. On-site private facilities and public facilities to be owned by the Owner, including water piping, fittings, domestic potable waterline and fire protection system supply waterline, valves, and fire hydrants.

B. Related Sections

1. Section 31 23 16 – Excavation
2. Section 31 25 00 – Erosion & Sedimentation Control

**1.2 REFERENCES**

A. American Society of Mechanical Engineers (ASME)

1. ASME B 16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

B. ASTM International (ASTM)

1. ASTM B88 - Seamless Copper Water Tube
2. ASTM D1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
3. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series)
4. ASTM D2564 - Poly (Vinyl Chloride) (PVC) Solvent Cement
5. ASTM D2672 - Poly (Vinyl Chloride) (PVC) Integrally Molded Bell Ends For Solvent - Cemented Pipe Joints.
6. ASTM D3139 - Joints for Plastic Pressure Pipes using Flexible Elastomeric Seals
7. ASTM F477 - Elastomeric Gaskets And Lubricant
8. ASTM F656 - Poly (Vinyl Chloride) (PVC) Cement Primer

C. American Water Works Association (AWWA)

1. AWWA C104 – Cement-Mortar Lining For Ductile-Iron Pipe And Fittings For Water
2. AWWA C105 – Polyethylene Encasement for Ductile Iron Piping for Water and other Liquids
3. AWWA C116 – Protective Fusion-Bonded Epoxy Coatings For The Interior And Exterior Surfaces Of Ductile-Iron And Gray-Iron Fittings For Watersupply Service
4. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
5. AWWA C153 - Ductile-Iron Compact Fittings For Water Service
6. AWWA C500 - Gate Valves for Water and Sewage Systems
7. AWWA C550 - Protective Interior Coatings For Valves And Hydrants
8. AWWA C504 - Rubber-Seated Butterfly Valves
9. AWWA C600 - Installation of Ductile-Iron Water Mains and Appurtenances
10. AWWA C605 - Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings For Water
11. AWWA C651 - Disinfecting Water Mains
12. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water Distribution

D. National Fire Protection Associations (NFPA)

1. NFPA 24 - Installation of Private Fire Service Mains and Their Appurtenances

E. Missouri Department of Natural Resources – 10 CS 60-10.010

## 1.3 QUALITY ASSURANCE

A. Products, where marked for compliance with code or test standards, shall also mark specific standard as required in the Contract Documents.

B. Perform installation in accordance with utility company or municipality requirements.

C. Valves: Mark manufacturer's name and pressure rating on valve body.

D. Perform disinfection of potable lines in accordance with AWWA C651.

## 1.4 SUBMITTALS

A. Product Data: Provide Project Engineer with data on pipe materials, pipe fittings, hydrants, valves, and accessories.

B. Manufacturer's Certificate: Certify that products meet or exceed state or local requirements.

C. Furnish 1 copy of results of meter test and hydrostatic pressure test to Owner and utility company upon completion of water distribution backfilling operations.

D. Project Record Documents:

1. Disinfection report: Record the following:

   a. Type and form of disinfectant used.
   b. Date and time disinfectant injection start and time of completion.
   c. Test locations.
   d. Initial and 24 hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
   e. Date and time of flushing start and completion.
   f. Disinfectant residual after flushing in ppm for each outlet tested.

2. Bacteriological report: Record the following:

   a. Date issued, project name, testing laboratory name, address, and telephone number.
   b. Time and date of water sample collection.
   c. Name of person collecting samples.
   d. Test locations
   e. Initial and 24 hour disinfectant residuals in ppm for each outlet tested.
   f. Coliform bacteria test results for each outlet tested.
   g. Certification that water conforms, or fails to conform, to bacterial standards.
   h. Bacteriologist's signature and authority.

3. Accurately record actual locations of piping mains, valves, connections, and top of pipe elevations.

4. Identify and describe unexpected variations to subsoil conditions and location of uncharted utilities.

## PART 2 – PRODUCTS

### 2.1 PIPE

A. Pipe sizes up to and including 3 inches that are installed below grade and outside building shall comply with the following:

1. Continuous HDPE pressure pipe meeting ASTM 2737: Pipe, AWWA C901, rated SDR 9 150).

    a. Pipe shall be ADS PolyFlex Potable Water Service Tubing (CTS) conforming to the minimum requirements of cell classification 445474E as defined in ASTM D3350.

B. Pipe sizes 4 to 16 inches that are installed below grade and outside building shall comply with one or combination of following:

1. Ductile Iron Water Pipe: AWWA C151, Pressure class 350 (4-12”) Pressure Class 250 (14-16”).

    a. Fittings: Either mechanical joint or push-on-joint, AWWA C153, and shall be coated with a 6-8 mil nominal thickness fusion bonded epoxy conforming to the requirements of AWWA C550 and C116, or cement mortar lined in accordance with AWWA C104.
    b. Elastomeric gaskets and lubricant: ASTM F477.

2. Polyvinyl Chloride (PVC) Water Pipe: Pipe, AWWA C900, rated DR 18 (Class 150), continually marked as required.

    a. Elastomeric gaskets and lubricant: ASTM F477 for smaller pipes.
    b. Pipe joints: Integrally molded bell ends, ASTM D3139.

### 2.2 VALVES

A. Gate Valves, 2-Inches and Larger:

1. Manufacturer and Model: Mueller Resilient Wedge Gate Valves or approved equal.

2. AWWA C500, Iron body, non-rising stem with square nut, single wedge, resilient seat, flanged or mechanical joint ends, control rod, post indicator where indicated on Construction Drawings, extension box and valve key.

B. Ball Valves, 2-Inches and Smaller:

1. Manufacturer and Model: Mueller Oriseal or approved equal.

2. Brass body, teflon coated brass ball, rubber seats and stem seals, Tee stem pre-drilled for control rod, AWWA compression inlet end, compression outlet with electrical ground connector, with control rod, extension box and valve key.

C. Butterfly Valves, From 2-Inch to 24-Inch: AWWA C504, Iron body, bronze disc, resilient replaceable seat, water or lug ends, infinite position lever handle.

D. Check Valves, Post Indicator Valves, and Backflow Preventors

1. Refer to Section 13900 - Fire Suppression in Architectural/Building Specifications

## 2.3 FIRE HYDRANTS

A. Fire Hydrants: Type as required by utility company/Local Fire Department and as shown on Construction Drawings.

B. Hydrant Extensions: Fabricate in multiples of 6-inches with rod and coupling to increase barrel length.

C. Hose and Steamer Connections: Match sizes with utility company, with two hose nozzles, one pumper nozzle.

D. Finish: Apply primer and 2 coats of enamel or special coating to color as required by utility company.

## 2.4 ACCESSORIES

A. Thrust Blocking: Place 3000 psi concrete to provide sufficient bearing area to transmit unbalanced thrust from bends, tees, caps, or plugs to undisturbed soil without loading undisturbed soil in excess of 2,500 pounds per square foot when water main pressure is 100 psi.

MINIMUM THRUST BLOCKING BEARING AREAS

| Pipe Diameter | Tees Sq. Ft | 90° Bend Sq. Ft | 45° Bend Sq. Ft | 22½° Bend Sq. Ft. | 11¼° Bend Sq. Ft. | 5 5/8 Bend Sq. Ft. | Cap/Plug Sq. Ft. |
|---|---|---|---|---|---|---|---|
| 3" | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 |
| 4" | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 |
| 6" | 1.5 | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.0 |
| 8" | 2.5 | 3.5 | 1.8 | 1.0 | 1.0 | 1.0 | 4.0 |
| 10" | 4.0 | 5.5 | 2.8 | 1.5 | 1.0 | 1.0 | 6.0 |
| 12" | 6.0 | 8.0 | 4.0 | 2.0 | 1.5 | 1.0 | 8.5 |
| 14" | 8.0 | 11.0 | 5.5 | 3.0 | 2.0 | 1.5 | 12.0 |
| 16" | 10.0 | 14.2 | 7.0 | 4.0 | 3.0 | 2.5 | 15.0 |
| 18" | 21.0 | 21.0 | 12.0 | 6.0 | 4.0 | 3.5 | 24.0 |

B. Locked mechanical joint fittings shall be installed where vertical changes in direction are required and, if approved by Owner and governing authority, can be installed in lieu of above thrust blocking requirements.

C. Polyethylene Encasement: Single layer of two ply cross-laminated high density polyethylene encasement per AWWA C105, Section 4.1.2, Type III, Class C (Black), Grade 33, tensile strength 5,000 psi minimum, elongation 100 percent, thickness nominal 0.004 inch (4 mil).

D. Trace Wire: Magnetic detectable conductor, (#12 Copper) brightly colored plastic covering imprinted with “Water Service” in large letters.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify that building service connection and municipal utility water main size, location, and depth are as indicated on Construction Drawings.

## 3.2 PREPARATION

A. Ream pipe and tube ends and remove burrs.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare pipe for connections to equipment with flanges or unions.

D. Protect benchmarks, property corners, and other survey monuments from damage or displacement. If marker needs to be removed it shall be referenced by licensed land surveyor and replaced, as necessary, by same.

## 3.3 TRENCHING AND BEDDING

A. Excavate pipe trench and place bedding material in accordance with Section 31 23 23.

## 3.4 INSTALLATION - PIPE AND FITTINGS

A. Maintain separation of water main from sanitary and storm sewer piping in accordance with state or local codes.

B. Install ductile iron pipe and fittings in accordance with AWWA C600.

C. Install PVC pipe and fittings in accordance with AWWA C605.

D. Ductile iron pipe and fittings shall be installed with polyethylene encasement around the pipe for the entire length of the project except where water main is within steel casing or is concrete encased. Install polyethylene encasement in accordance with AWWA C105, Method A.

E. Install pipe to allow for expansion and contraction without stressing pipe or joints or as specified by pipe manufacturer.

F. Install access fittings in accordance with local codes to permit disinfection of water system performed under this Section.

G. Connections with Existing Pipelines: Where connections are made between new work and existing piping, make connection using suitable fittings for conditions encountered. Make each connection with existing pipe at time and under conditions with least interference with operation of existing pipeline and in compliance with local utility company.

H. Form and place concrete for thrust blocks or other specified methods of retainage at each change of direction or end of pipe main.

I. Place pipe to depth in accordance with Section 31 23 16 and the details in the plans.

J. Backfill trench in accordance with Section 31 23 23 and the details in the plans.

K. Install trace wire continuous over top of non-metal pipe. Bury a minimum of 6 inches below finish grade, and above pipeline.

## 3.5 INSTALLATION - VALVES AND HYDRANTS

A. Install gate valves as indicated on Construction Drawings. Support valve on concrete pads with valve stem vertical and plumb. Install valve boxes in manner that will not transmit loads, stress, or shock to valve body. Center valve box over operating nut of valve vertical and plumb. Securely fit valve box together leaving cover flush with finished surface.

B. Install fire hydrant assemblies as indicated on Construction Drawings in vertical and plumb position with steamer/pumper nozzle pointed perpendicular to traffic where hydrant is adjacent to street, roadway, or parking lot drive or toward protected building unless otherwise directed by local authorities. Support hydrant assembly on concrete pad and firmly brace on side opposite inlet pipe against undisturbed soil and concrete blocking. Place minimum of 6-cubic feet of crushed stone or gravel around hydrant base and barrel after thrust blocking has cured at least 24 hours. Maintain vertical position of hydrant backfilling and compacting.

## 3.6 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Disinfect distribution system with chlorine before acceptance for domestic operation. Chlorine dosage shall be not less than 50 parts per million. Flush lines before introduction of chlorinating materials and after contact period of not less than 24 hours. Flush with clean water after contact period until residual chlorine content is not greater than 1.0 part per million. Flush water discharged from water supply lines or hydrants shall not be allowed to discharge directly onto exposed soil or turf which could result in erosion of soil. If potential for erosion exists at discharge point, measures shall be taken to prevent erosion. Open and close valves in lines being disinfected several times during contact period. After disinfection, take water sample and bacteriological test in accordance with AWWA C651. Satisfactory disinfection shall be demonstrated in accordance with the requirements of the Missouri Department of Natural Resources and the City of Buffalo, MO. Do not place distribution system in service until approval is obtained from local governing authorities.

B. Contractor shall provide a means of neutralizing the super-chlorinated water before releasing into the environment. This may be accomplished by either a method of dechlorinization, direct release into a detention area approved by Owner, or any method acceptable to federal, state, and local codes. Direct release to open ground shall not be allowed, unless contained within an on site detention facility with 6" permanent storage. In this case, the Contractor shall time the release to assure that no rainstorms are imminent. The intent of this condition is to allow the majority of the chlorine to evaporate into the atmosphere before a rainstorm has the opportunity to wash the residual downstream. Contractor shall not release super-chlorinated water directly into the sanitary sewer system, private or public, nor any storm drain system not directly discharging into the detention facility.

## 3.7 SERVICE CONNECTIONS

A. Provide water service connection in compliance with utility company requirements including reduced pressure backflow preventer (if required) and water meter with by-pass valves and sand strainer.

## 3.8 FIELD QUALITY CONTROL

A. Test water distribution system pipe installed below grade and outside building in accordance with the following procedures:

1. Perform testing of pipe materials, joints, and other materials incorporated into construction of water mains and force mains to determine leakage and water tightness. Test pressure pipeline in accordance with Section 4 of AWWA C600 and NFPA 24. In the event state or local code requires more stringent test, more stringent test shall take precedence.

2. Pressure Test: After pipe has been laid, subject newly laid pipe or valved section to hydrostatic pressure of at least 1.5 times working pressure at point of testing and not less than 1.25 times working pressure at highest point along test section.

3. Leakage Test: Conduct leakage test concurrently with pressure test. Leakage is defined as quantity of water that must be supplied into newly laid pipeline or valved section thereof to maintain pressure within 5 psi of specified test pressure after air in pipeline has been expelled and pipeline has been filled with water. Leakage shall not be measured by drop in pressure in test section over period of time.

    a. Leakage test for ductile iron pipe shall not be greater than that determined by the following formula:

        L= SD√133,200

        Where: L = allowable leakage, (gallons per hour)
        S = length of pipe tested, (feet)
        D = nominal diameter of pipe, (inches)
        P = average test pressure during test, (psig)

    b. Leakage test for PVC pipe shall be in accordance with AWWA Standard C605.

4. Visible Leakage: Repair visible leaks regardless of amount of leakage measured.

5. Acceptance of Installation: If test of pipe laid in place discloses leakage greater than that specified, Contractor shall, at his own expense, locate leak and make repairs as necessary until leakage is within specified allowance. Supply water for testing at no expense to Owner.

**END OF SECTION 33 10 00**

## SECTION 33 31 11 - SANITARY SEWAGE SYSTEMS

## GENERAL

### 1.1 SUMMARY

A. Section Includes
   1. Sanitary sewer drainage piping, fittings, accessories, cleanouts, and bedding.
   2. Connection of site sanitary sewer system to municipal sanitary sewer systems.

B. Related Sections
   1. Section 31 23 16 – Excavation
   2. Section 33 05 13 - Sewer Manholes, Frames, and Covers
   3. Section 03 30 00 – Cast-in-Place Concrete

### 1.2 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. Publications are referenced within the text by the basic designation only.

B. ASTM International (ASTM)
   1. ASTM A74 - Cast Iron Soil Pipe and Fittings
   2. ASTM A746 - Ductile Iron Gravity Sewer Pipe
   3. ASTM C425 - Compression Joints for Vitrified Clay Pipe and Fittings
   4. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings
   5. ASTM C700 - Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
   6. ASTM D2241 - Poly (vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
   7. ASTM D2657 - Heat-Joining Polyolefin pipe and Fittings
   8. ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
   9. ASTM D3035 - Polyethylene (PE) Plastic Pipe Using Flexible Elastomeric Seals
   10. ASTM D3139 - Joints for Plastic Pressure Pipe Using Flexible Elastomeric Seals
   11. ASTM D3261 - Butt Heat Fussion Polyethylene (PE) Plastic Fittings For Polyethylene Plastic Pipe And Tubing
   12. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe
   13. ASTM F1417- Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.

C. American Water Works Association (AWWA)
   1. AWWA C111 - Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings
   2. AWWA C600 - Ductile-Iron Water Mains And Their Appurtenances
   3. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, 4 In. Through 12 In, For Water Distribution
   4. AWWA C901 - Polyethylene (PE) Pressure Pipe, Tubing And Fittings 1/2 Inch Through 3 Inches, For Water Distribution
   5. AWWA C906 - Polyethylene (PE) Pressure Pipe And Fittings, 4 Inch Through 63 Inch, For Water Distribution

### 1.3 SUBMITTALS

A. Project Record Documents:
   1. Accurately record actual locations of pipe runs, connections, cleanouts, and invert elevations.
   2. Identify and describe unexpected variations to subsoil conditions and location of uncharted utilities.

### 1.4 PROJECT CONDITIONS

A. Coordinate work with termination of sanitary sewer connection outside building and connection to municipal sewer utility service.

**PRODUCTS**

**1.5 SEWER PIPE, FITTINGS, AND JOINTS**

A. Polyvinyl Chloride Pipe (PVC): ASTM D 3034, rated SDR 26 unless otherwise specified by the utility company. Pipe shall be continually marked with manufacturer's name, pipe size, cell classification, SDR rating, and ASTM D 3034 classification.
   1. Pipe joints: Integrally molded bell ends, ASTM D 3034, Table 2, with factory supplied elastomeric gaskets and lubricant.

**1.6 PIPE ACCESSORIES**

A. Pipe Joints: Mechanical clamp ring type, stainless steel expanding and contracting sleeve, neoprene-ribbed gasket for positive seal.

B. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, cleanouts, reducers, traps, etc.

**1.7 CLEANOUTS AND MANHOLES**

A. Manholes shall conform to Section 02536.

B. Lid and Frame: Provide in accordance with Section 02536. Provide traffic grade and rated covers and frames where cleanouts and manholes are within pavement, with the letters “SSCO” or “SANITARY SEWER” respectively cast into the cover.

C. Shaft Construction: Cast iron shaft of internal diameter as specified on Construction Drawings with 2500 psi concrete collar for cleanouts.

**1.8 APPURTENANCES**

A. Trace Wire: Magnetic detectable conductor (#12 copper), brightly colored plastic covering, imprinted with “Sanitary Sewer Service” in large letters.

**EXECUTION**

**1.9 EXAMINATION**

A. Verify that trench cut and excavation is ready to receive work and excavations, dimensions, and elevations are as indicated on Construction Drawings.

**1.10 PREPARATION**

A. Hand trim excavations to required elevations. Correct over excavation with bedding material.

B. Remove large stones or other hard matter that could damage pipe or impede consistent backfilling or compaction.

**1.11 BEDDING**

A. Excavate trench and place bedding material in accordance with Section 02300.

**1.12 INSTALLATION - PIPE**

A. Install type and class of pipe as shown on the drawings. Pipes shall be laid and maintained to the required line and grade with necessary fittings, bends, manhole risers, cleanouts and other appurtenances placed at the required locations. The pipe shall be installed with uniform bearing under the full length of the barrel of the pipe. The pipe shall be inspected for defects and cracks before being lowered into the trench. Defective, damaged or unsound pipe, or pipe that has had its grade disturbed after laying shall be taken up and replaced. Commence installation at lowest point with the bell end upgrade.

B. No pipe shall be laid in water or when trench conditions are unsuitable for work.

C. Pipe connecting to manholes or other structures shall terminate flush inside of the structure wall.

D. Joints for PVC and CISP shall be thoroughly lubricated with an approved lubricant before pipe sections are slipped together. Open ends shall be fully protected with a stopper to prevent earth or other material from entering the pipe during construction. Carefully free interior of the pipe from dirt, cement and other deleterious material as the work progresses.

E. Maintain separation of potable water main from sewer piping at crossings a minimum of 10 feet horizontal and 18 inches vertical.

F. Install HDPE piping and fittings to AWWA C901 and C906. Butt fusion welded per ASTM D3261.

G. Route pipe in straight line parallel to roads, buildings and adjacent utilities and as shown on the drawings.

H. Establish elevations of buried piping with sufficient cover as recommended by pipe manufacturer to ensure not less than 3 feet of cover, except as noted on drawings.

I. Form and place concrete for thrust blocks at each elbow of pipe force main. See construction drawing for details of construction.

J. Backfill trench in accordance with Section 02300.

K. Install trace wire continuous over top of non-metal pipe. Bury 6 inches minimum below finish grade, above pipeline.

**1.13 INSTALLATION – CLEANOUTS AND MANHOLES**

A. Form bottom of excavation clean and smooth to correct elevation.

B. For cleanouts, form and place cast-in-place concrete base pad with provision for sanitary sewer pipe to be installed to proper elevations.

C. For manholes, construct inverts according to the following guidelines:
   1. Invert channel shall be smooth and accurately shaped to a semicircular bottom to match with the inside of the adjacent sewer section.
   2. Invert channels and structure bottoms shall be shaped with mortar and lean concrete.
   3. Changes in size and grade of invert shall be made gradually and evenly.
   4. Changes in the direction of the sewer entering branch or branches shall have a true curve of as large a radius as the manhole will permit.

D. For manholes, provide manhole rings, frame, and cover as shown on the construction drawings.

**1.14 FIELD QUALITY CONTROL**

A. Field quality control shall be conducted by the Contractor in accordance with Section 01452.

B. Pipes and joints shall not be completely backfilled until after inspection, testing, and approval by the Owner and local jurisdiction.

C. Prior to testing for leakage, the pipe trench shall be backfilled to at least the spring line of the pipe. If required to prevent pipe movement during testing, additional backfill shall be added leaving the pipe joints uncovered to permit inspection.

D. Leakage testing of all manholes shall be in accordance with ASTM C1244-93 or C969-94.

E. Exfiltration Test
1. Each section of sewer line between successive manholes shall be tested by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole, using stoppers.
2. Fill the manhole and pipe with water to a point which produces a maximum of 3 feet of head above the invert of the sewer at the center of the upper manhole; or if groundwater is present, 3 feet of head above the average adjacent groundwater level.
3. The allowable leakage shall be 200 gal/inch of pipe diameter/mile/day

F. Infiltration Test
1. If excessive ground water is encountered in the construction of a section of the sewer, the exfiltration test shall not be used.
2. The upper and lower ends of the sewer to be tested shall be closed sufficiently to prevent the entrance of water.
3. Pumping of ground water shall be discontinued for at least 3 days; then infiltration shall be tested.
4. Infiltration into each section of sewer between adjoining manholes shall not exceed that allowed for the exfiltration test, except that head conditions shall be a maximum of 6 feet.
5. The allowable leakage shall be 200 gal/inch of pipe diameter/mile/day.

G. The Exfiltration Test may be limited to the manholes only when the authority having jurisdiction does not require the test and the construction manager waives the test. The Infiltration Test will always be required when excessive ground water is encountered in addition to the air test.

H. Air Test: Gravity systems shall be air tested between manholes at 3.5 psi for 5 minutes per ASTM F1417 for plastic pipes.

I. Deflection Test:
1. Deflection tests shall be conducted on all plastic pipe using a mandrel with a diameter equal to 95 percent of the inside diameter of the pipe. The test shall be performed without mechanical pulling devices.
2. Allowable Deflection: Maximum allowable pipe deflection shall not exceed 5 percent of nominal inside diameter.
3. Mandrel: Mandrel, go/no-go, device shall be cylindrical in shape and constructed with either 9 or 16 evenly spaced arms or prongs. Mandrels with fewer arms will be rejected as not sufficiently accurate. Contact length of mandrel's arms shall equal or exceed nominal inside diameter of sewer to be inspected. Critical mandrel dimensions shall carry tolerance of 0.01-inch maximum. Contractor shall provide mandrel and necessary equipment for mandrel test.
4. Procedure: Mandrel shall be hand-pulled through flexible pipe sewer lines no earlier than 30 days after trench has been completely backfilled. Sections of sewer not passing mandrel shall be uncovered and rebedded, rerounded, or replaced to satisfaction of Owner or governing agency. Repaired section shall be retested.

J. Provide measuring devices, meters, water, materials, and labor for making the required tests.

K. Tests shall be conducted in the presence of the Construction Manager or his designee. Test data shall be submitted to the Engineer for review and approval.

**END OF DOCUMENT 33 31 11**

## SECTION 33 40 00 – STORM DRAINAGE UTILITIES

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Storm sewer system including pipes and bedding material indicated on drawings.

B. Fittings and accessories to complete the drainage system.

### 1.2 RELATED WORK

A. Specified elsewhere:

1. Section 31 23 16 – Excavation
2. Section 31 23 23 – Fill
3. Section 31 25 00 – Erosion & Sedimentation Control
4. Section 33 49 00 – Storm Drainage Structures

### 1.3 REFERENCES. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise noted, govern the work.

A. Missouri Department of Transportation (MoDOT): Standard Specifications for Highway, including all addenda.

### 1.4 REGULATORY REQUIREMENTS

A. Conform to the applicable portions of Section 203, 1026 and 1041 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway, including all Supplemental Specifications and Recurring Special Provisions.

### 1.5 DELIVERY, STORAGE AND HANDLING

A. Transport, deliver, unload, store and handle all pipe and fittings to prevent damage to materials or work.

B. All damaged, broken or otherwise defective materials will be rejected.

C. Store all circular gaskets and special lubricants in packaged materials with manufacturer’s name, brand and all other specific data plainly marked thereon.

**1.6 SUBMITTALS**

A. Accurately record actual locations of pipe runs, connections, manholes, inlets and invert elevations.

B. Submit product data for approval.

**PART 2 – PRODUCTS**

**2.1 STORM SEWERS**

A. HP Storm Pipe Dual Wall PP Pipe (High-performance Polyethylene Pipe) for gravity-flow storm drainage conforming to ASTM F2736 with smooth interior.

B. Reinforced Concrete Pipe (RCP) conforming to Section 1026 of the MoDOT Standard Specifications for the size, class & type of sewer shown on the plans.

**2.2 JOINT MATERIAL**

A. HP Pipe:

1. Joints shall be water tight conforming to ASTM D3212. The spigot joint shall have two gaskets meeting the requirements of ASTM F477.

B. RCP Pipe:

1. Preformed Flexible Gaskets – Conforming to Section 733 of the MoDOT Standard Specifications.

**PART 3 – EXECUTION**

**3.1 INSPECTION**

A. Site Inspection: Inspect site and verify all grades, levels and conditions are as indicated on the layout drawings.

B. Inspect all areas and conditions where drainage structures are to be installed.

1. Inspect field conditions before ordering materials.

2. Notify Engineer in writing of conditions detrimental to proper and timely completion of work.

3. Do not proceed with work until unsatisfactory conditions are corrected.

**3.2 COORDINATION**

A. Schedule work and notify all crafts in time so provisions for their work can be made without delaying project progress.

B. All installations conform to lines and grades shown on drawings.

1. Place structures where indicated on drawings unless their location is changed by the Engineer.
2. Field conditions dictate deviation from drawings, no change made without written authorization of the Engineer.

**3.3 PREPARATION**

A. Hand trim excavations to required elevations. Correct over excavation with fine aggregate.

B. Remove large stones or other hard matter that could damage piping or impede consistent backfilling or compaction.

## 3.4 BEDDING

A. Excavate pipe trench in accordance with Section 203 of MoDOT's Standard Specifications for work of this section.

B. Place bedding material at trench bottom, level materials in a continuous layer.

## 3.5 INSTALLATION OF STORM SEWERAGE SYSTEM

A. Storm Sewer Lines: Install pipe, fittings and accessories in accordance with MoDOT's Standard Specifications.

## 3.6 HORIZONTAL SEPARATION – WATER MAINS AND SEWERS

A. Water mains shall be located at least ten feet horizontally from any existing or proposed drain, storm sewer, sanitary sewer, combined sewer or sewer service connection.

B. Water mains may be located closer than ten feet to a sewer line when:

1. Local conditions prevent a lateral separation of ten feet; and

2. The water main invert is at least 18 inches above the crown of the sewer; and

3. The water main is either in a separate trench or in the same trench on an undisturbed earth shelf located to one side of the sewer.

C. When it is impossible to meet (1) or (2) above, both the water main and drain or sewer shall be constructed of slip-on mechanical joint cast or ductile iron pipe, asbestos-cement pressure pipe, prestressed concrete pipe, or PVC pipe equivalent to water main standards of construction. The drain or sewer shall be pressure tested to the maximum expected surcharge head before backfilling.

## 3.7 VERTICAL SEPARATION – WATER MAINS AND SEWERS

A. A water main shall be separated from a sewer so that its invert is a minimum of 18 inches above the crown of the drain or sewer whenever water mains cross storm sewers, sanitary sewers of sewer service connections. The vertical separation shall be maintained for that portion of the water main located within ten feet horizontally of any sewer or drain crossed. A length of water main pipe shall be centered over the sewer to be crossed with joints equidistant from the sewer or drain.

B. Both the water main and sewer shall be constructed of slip-on mechanical joint cast or ductile iron pipe, asbestos-cement pressure pipe, prestressed concrete pipe, or PVC pipe equivalent to water main standards of construction when:

1. It is impossible to obtain the proper vertical separation as described in (1) above;

   or

2. The water main passes under a sewer or drain.

C. A vertical separation of 18 inches between the invert of the sewer or drain and the crown of the water main shall be maintained where a water main crosses under a sewer. Support the sewer or drain lines to prevent settling and breaking the water main, as shown on the plans or as approved by the Construction Manager.

D. Construction shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer or drain line is at least ten feet.

**END SECTION 33 40 00**

# SECTION 33 49 00 – STORM DRAINAGE STRUCTURES

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. New precast storm sewer inlets and manholes with concrete tops and metal frames, lids or grates and accessories.

B. Connection of new storm sewer pipe to existing inlet or manhole structure.

C. Adjust existing manholes, inlets, valve boxes and meter vaults as required by the utility company or the Engineer.

D. New precast concrete flared end sections and headwalls.

### 1.2 RELATED WORK

A. Specified elsewhere:

1. Section 31 23 16 – Excavation
2. Section 33 40 00 – Storm Drainage Utilities

### 1.3 REFERENCES. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise noted, govern the work.

A. Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all addenda.

B. Missouri Department of Natural Resources.

C. Applicable MoDOT Highway Standards – Attached at end of this Section.

### 1.4 REGULATORY REQUIREMENTS

A. Conform to the applicable portions of Section 731, 732 and 614 of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway Construction, including all Supplemental Specifications and Recurring Special Provisions.

## PART 2 – PRODUCTS

### 2.1 PRECAST MANHOLE SECTIONS, STEPS, FRAMES AND LIDS

A. The Contractor shall be required to submit shop drawings of each structure for approval in accordance with these documents, prior to fabricating or delivering any manholes.

B. Manhole and inlet sections, castings and accessories shall conform to Section 614 of MoDOT's Standard Specifications, MoDOT's Highway standards and the project details and drawings included with the contract documents.

C. Connections for storm sewer pipes shall be grouted in place with non-shrink grout material.

D. Joints between precast manhole sections and under the casting frame shall be watertight and sealed by means of preformed butyl resin rope or by O-ring rubber gasket. Seal material shall not shrink, harden or oxidize with age. Installation shall be according to manufacturer's recommendations and as shown on the drawings.

E. The Contractor shall adjust the manhole or inlet casting to the final ground line as shown on the plans or as directed by the Engineer in the field. Concrete “adjustment rings” having the same inside diameter as the casting may be used to raise the casting up to a maximum of 6”.

**PART 3 – EXECUTION**

**3.1 COORDINATION**

A. Schedule work and notify all crafts in time so that provisions for their work can be made without delaying the project.

**3.2 INSTALLATION**

A. Excavation

In order to permit the joints to be mortared properly and also to permit proper compaction of the backfill material, the excavation shall be made to a diameter of at least two feet greater than the outside diameter of the structure.

B. Subbase Preparation

Adequate foundation for manhole structures shall be obtained by removal and replacement of unsuitable material with well-graded granular material, by tightening with coarse ballast rock, or by such other means provided for foundation preparation of the connected sewers.

C. Manhole Base Installation (Precast Base)

A well-graded granular bedding course conforming to the requirements for aggregate for trench backfill (Section 31 23 23), not less than four inches in thickness and extending to the limits of the excavation, shall be firmly tamped and made smooth and level to assure uniform contact and support of the precast element. A precise base section shall be carefully placed on the prepared bedding so as to be fully and uniformly supported in true alignment and making sure that all entering pipes can be inserted on proper grade.

D. Precast Manholes

1. Precast manholes may be constructed with a precast base section or a monolithic base structure as specified. Precast sections shall be placed and aligned to provide vertical sides and vertical alignment of the ladder runs. The completed manhole shall be rigid, true to dimensions and shall be watertight.

2. All lift holes in precast elements shall be completely filled with an approved bitumastic material. All joints between precast elements on sanitary sewer manholes shall be made with an o-ring rubber or neoprene gasket.

E. Construction Detail

1. Inlet and Outlet Pipes. Pipe or tile placed in the masonry for inlet or outlet connections shall extend through the wall and beyond the outside surface of the wall a sufficient distance to allow for connections, and the masonry shall be carefully constructed around them so as to prevent leakage along the outer surfaces. Special care shall be taken to see that the openings through which pipes enter the structure are completely sealed by use of a nonshrink grout.

2. Placing Castings. Casting adjustments of less than two inches shall be with mortar. The mortar shall be mixed in proportion of one part cement to three parts sand, by volume, based on dry materials. Castings shall be set accurately to the finished elevation so that no subsequent adjustment will be necessary. Castings shall be sealed to concrete sections with bitumastic material.

3. Manhole Inverts. Construct manhole flow channels of concrete or sewer pipe, which shall be of semicircular section conforming to the inside diameter changes in size and grade gradually, and changes in direction shall be by true curves. Provide channels for all connecting sewers to each manhole and benching shown on the drawings.

F. Backfill

The space between the sides of the excavation and the outer surfaces of the manhole shall be backfilled with aggregate for trench backfill when the manhole is in a pavement or when the nearest point of the excavation for the manhole falls within two feet of the paved edge.

G. Cleaning

All newly constructed inlets and manholes and any existing structures modified shall be cleaned of all accumulation of silt, debris or foreign matter of any kind and shall be free of such accumulations at the time of final inspection.

**END OF SECTION 33 49 00**

## SECTION 34 41 16 – TRAFFIC CONTROL EQUIPMENT

## PART 1 – GENERAL

### 1.1 WORK INCLUDES

A. Layout, installation, maintenance and removal of temporary traffic control devices to prevent users of the off-site roadways and pedestrian-ways from entering the construction areas, and to direct them around the work zone.

B. Layout, furnish and install permanent signs as shown in the plans.

C. Remove, store and reinstall existing signs as shown in the plans or required by construction.

### 1.2 RELATED WORK (RESERVED)

### 1.3 REGULATORY REQUIREMENTS

A. Conform to applicable portions of the Missouri Department of Transportation (MoDOT): Standard Specifications for Highway.

B. Conform to the MoDOT Highway Standards included in the project details of these contract documents.

C. Conform to the Manual on Uniform Traffic Control Devices.

### 1.4 SUBMITTALS

A. Contractor to submit shop drawings prior to ordering and manufacturing any permanent signs.

## PART 2 – PRODUCTS

### 2.1 TRAFFIC CONTROL DEVICES

A. Temporary Traffic Control Devices: As specified per MoDOT requirements.

B. Sign Panels: Furnish signs of the type, color and size shown in the plans or approved by the Owner, in accordance with MoDOT Standard Specifications, the Manual on Uniform Traffic Control Devices and the manufacturer’s instructions.

C. Posts: Furnish 2” square black powder coated telescoping tube steel posts with galvanized sign-mounting hardware for each sign.

## PART 3 – EXECUTION

### 3.1 PREPARATION

A. Verify existing conditions. Field verify underground utilities prior to sign installation. Primary utilities of concern of shallow depths are irrigation, electric, telephone, cable and gas.

B. Evaluate placement of traffic control devices in addition to the devices shown on the plans.

C. Consider flow of traffic adjacent to site.

D. Obtain required street and/or sidewalk closure permits from City.

E. Provide Owner & City with 72 hours' notice prior to initiating traffic control.

F. Verify sign locations will not conflict with landscaping or other obstructions.

G. Cost related to repair damaged surface and subsurface facilities shall be paid for by the Contractor at no additional expense to the Owner.

### 3.2 INSTALLATION

A. Implement traffic control devices to promote flow of traffic.

B. Ensure traffic control devices are visible at night.

C. Install signs as shown in the plans.

### 3.3 MAINTENANCE

A. Correct traffic control devices that fail or are shifted by traffic.

B. Adjust traffic control devices to respond to changes in traffic patterns and flow.

### 3.4 REMOVAL

A. Upon final completion of the project, remove all traffic control devices.

**END SECTION 34 41 16**