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CONSTRUCTION DOCUMENTS
PROJECT MANUAL
Bid Set

August 14, 2017

VOLUME TWO

Vines Architecture, Inc.
530 Hillsborough St.
Raleigh, North Carolina 27603
(919) 755-1975

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**SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION**

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes pipe, fittings, valves, and connections for sprinkler, standpipe and fire hose, and combination sprinkler and standpipe systems.

1.2 SUBMITTALS

- A. Submittal Procedures: Refer to Division 1 for Submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Product Data: Submit manufacturer's catalogue information. Indicate valve data and ratings.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Design the application of hangers and supports for seismic requirements under direct supervision of a Professional Engineer licensed in North Carolina and experienced in the design of this work. Seismic restraints are to be in accordance with Section 9.6 of ASCE 7-02.

1.3 CLOSEOUT SUBMITTALS

- A. Execution and Closeout Requirements: Refer to Division 1 for Closeout procedures.
- B. Project Record Documents: Record actual locations of components and tag numbering.
- C. Operation and Maintenance Data: Submit spare parts lists.

1.4 QUALITY ASSURANCE

- A. Provide fire sprinkler piping located in plenums with peak optical density not greater than 0.5, average optical density not greater than 0.15, and flame spread not greater than 5 feet (1.5 m) when tested in accordance with UL 1887.
- B. Perform Work in accordance with NFPA 13 standard, NFPA 14 standard, City of Wilmington Public Work's standard, and the State of NC.
- C. Maintain one copy of each document on site.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of Project.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer, NC licensed sprinkler contractor.

1.6 PRE-INSTALLATION MEETINGS

- A. Administrative Requirements: Refer to Division 1 for Pre-installation meeting.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Product Requirements: Refer to Division 1 for Product storage and handling requirements.
- B. Deliver and store valves in shipping containers, with labeling in place.
- C. Furnish cast iron and steel valves with temporary protective coating.
- D. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.8 WARRANTY

- A. Execution and Closeout Requirements: Refer to Division 1 for Product warranties and product bonds.

1.9 EXTRA MATERIALS

- A. Execution and Closeout Requirements: Refer to Division 1 for Spare parts and maintenance products.

PART 2 PRODUCTS

2.1 VALVES

- A. Furnish materials in accordance with State of NC standards.
- B. Gate Valves:
1. Up to and including 2 inches: Bronze body and trim, rising stem, hand wheel, solid wedge or disc, threaded ends.
 2. Over 2 inches: Iron body, bronze trim, rising stem pre-grooved for mounting tamper switch, hand wheel, OS&Y, solid bronze or cast iron wedge, grooved ends.
 3. Over 4 inches: Iron body, bronze trim, non-rising stem with bolted bonnet, solid bronze wedge, flanged ends, iron body indicator post assembly.
- C. Globe or Angle Valves:
1. Up to and including 2 inches: Bronze body, bronze trim, rising stem and hand wheel, inside screw, renewable rubber disc, threaded ends, with back seating capacity packable under pressure.
 2. Over 2 inches: Iron body, bronze trim, rising stem, hand wheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.
- D. Ball Valves:
1. Up to and including 2 inches: Bronze two piece body, brass, chrome plated bronze, or stainless steel ball, teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends with union.
 2. Over 2 inches: Manufacturers: Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle [or gear drive hand wheel for sizes 10 inches and over], flanged.
- E. Butterfly Valves:
1. Bronze Body: Stainless steel disc, resilient replaceable seat, threaded or grooved ends, extended neck, hand wheel and gear drive and integral indicating device, and built-in tamper proof switch rated 10 amp at 115 volt AC.
 2. Cast or Ductile Iron Body: Cast or ductile iron, chrome or nickel plated ductile iron or aluminum bronze disc, resilient replaceable EPDM seat, wafer, lug, or grooved ends. With extended neck, hand wheel and gear drive and integral indicating device, and internal tamper switch rated 10 amp at 115 volt AC.
- F. Check Valves:

1. Up to and including 2 inches: Bronze body and swing disc, rubber seat, threaded ends.
2. Over 2 inches: Iron body, bronze trim, swing check with rubber disc, renewable disc and seat, flanged ends with automatic ball check.
3. 4 inches and Over: Iron body, bronze disc with stainless steel spring, resilient seal, threaded, wafer, or flanged ends.

G. Drain Valves:

1. Compression Stop: Bronze with hose thread nipple and cap.
2. Ball Valve: Brass with cap and chain, 3/4 inch hose thread.

2.2 BURIED PIPING

- A. Steel Pipe: ASTM A53/A53M, Grade B, Schedule 40 black galvanized, with ASME C105 polyethylene jacket, or double layer, half-lapped 10 mil polyethylene tape.
1. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
 2. Joints: AWS D1.1, welded.

2.3 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A53/A53M, Grade B, Schedule 10 for 2-1/2" and larger black steel. Schedule 40 for 2" and smaller black. ASTM A135 UL listed, threadable, light wall.
1. Malleable Iron Fittings: ASTM 47 for piping up to 2".
 2. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers ;for piping 2-1/2" and larger.
 3. Mechanical Formed Fittings: Carbon-steel housing with integral pipe stop and O-ring pocked and O-ring uniformly compressed into permanent mechanical engagement onto pipe.
- B. Cast Iron Pipe: AWWA C151.
1. Fittings: AWWA C110, standard thickness.
 2. Joints: AWWA C111, rubber gasket.
 3. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped composition sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

2.4 PIPE HANGERS AND SUPPORTS

- A. Conform to NFPA 13 and NFPA 14.
- B. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.

- C. Hangers for Pipe Sizes 2 inch and Over: Carbon steel, adjustable, clevis.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- E. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
- F. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.
- G. Vertical Support: Steel riser clamp.
- H. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install piping in accordance with NFPA 13 for sprinkler systems, NFPA 14 for standpipe and hose systems, and NFPA 24 for service mains.
- B. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- C. Install piping to conserve building space, to not interfere with use of space and other work.
- D. Group piping whenever practical at common elevations.
- E. Install pipe sleeve at piping penetrations through footings, partitions, walls, and floors. Seal pipe and sleeve penetrations to maintain fire resistance equivalent to fire separation.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Pipe Hangers and Supports:

1. Install in accordance with NFPA 13 and NFPA 14.
 2. Install hangers to with minimum 1/2 inch space between finished covering and adjacent work.
 3. Place hangers within 12 inches of each horizontal elbow.
 4. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 6. Where installing several pipes in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Slope piping and arrange systems to drain at low points. Install eccentric reducers to maintain top of pipe level.
- I. Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding. Refer to Section 09 90 00.
- J. Do not penetrate building structural members unless indicated.
- K. Where more than one piping system material is specified, install compatible system components and joints. Install flanges, union, and couplings at locations requiring servicing.
- L. Die cut threaded joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.
- M. Install valves with stems upright or horizontal, not inverted. Remove protective coatings after installation.
- N. Install gate or butterfly valves for shut-off or isolating service.
- O. Install drain valves at main shut-off valves, low points of piping and apparatus.
- P. Where inserts are omitted, drill through concrete slab from below and install through-bolt with recessed square steel plate and nut above slab.

3.3 INTERFACE WITH OTHER PRODUCTS

- A. Inserts:
1. Install inserts for placement in concrete forms.
 2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 3. Install hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

3.4 CLEANING

- A. Execution and Closeout Requirements: Refer to Division 1 for Final cleaning.
- B. Clean entire system after other construction is complete.

END OF SECTION 21 0500

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SECTION 210548**VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT****PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.
- B. The seismic design classification for this building is C. Seismic design, seismic bracing and supports are required.

1.2 SUMMARY

- A. Section Includes
 - 1. Snubbers.
 - 2. Restraint channel bracings.
 - 3. Restraint cables.
 - 4. Seismic-restraint accessories.
 - 5. Mechanical anchor bolts.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.4 ACTION SUBMITTALS

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

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

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Calculations and design of seismic bracing and supports shall be performed by a Professional engineer registered in the state of North Carolina.
- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

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

1.7 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading
 - 1. Site Class as Defined in the IBC: D.
 - 2. Seismic Design Category: C
 - 3. Assigned Building Category as Defined in the IBC: III.
 - a. Component Importance Factor: Life Safety Systems, Sprinkler Piping, and Natural Gas Piping 1.5, Other systems 1.0
 - b. Component Response Modification Factor: Per ASCE 7-05, chapter 13.
 - c. Component Amplification Factor: Per ASCE 7-05, chapter 13.
 - 4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.218G.
 - 5. Design Spectral Response Acceleration at 1.0-Second Period: 0.091G.
 - 6. Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or OSHPD or an agency acceptable to authorities having jurisdiction.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- a. Ace Mountings Co., Inc.
- b. California Dynamics Corporation.
- c. Isolation Technology, Inc.
- d. Kinetics Noise Controls, Inc.
- e. Mason Industries, Inc.
- f. Vibration Eliminator Co., Inc.
- g. Vibration Isolation.
- h. Ace Mountings Col, Inc.

2.2 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Kinetics Noise Control, Inc.
 - 2. Mason Industries, Inc.
 - 3. Vibration Mountings & Controls, Inc.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

2.3 RESTRAINT CHANNEL BRACINGS

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

2.4 RESTRAINT CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Kinetics Noise Control, Inc.
 - 2. Loos & Co., Inc.
 - 3. Vibration Mountings & Controls, Inc.

- B. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.5 SEISMIC-RESTRAINT ACCESSORIES

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

2.6 MECHANICAL ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hilti, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.

Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.7 ADHESIVE ANCHOR BOLTS

- A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for

interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 – EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATIONS

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified.
- B. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- C. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- D. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 3. Brace a change of direction longer than 12 feet.
- E. Install cables so they do not bend across edges of adjacent equipment or building structure.
- F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- J. Drilled-in Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

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

3.6 ADJUSTING

- A. Adjust isolators after piping 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.

3.7 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

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

END OF SECTION 210548

SECTION 211313**WET-PIPE SPRINKLER SYSTEMS****PART 1 GENERAL****1.1 SUMMARY**

- A. Section includes wet-pipe sprinkler system, system design, installation, and certification.

1.2 SYSTEM DESCRIPTION

- A. System to provide coverage for entire building.
- B. Provide hydraulically designed system to NFPA 13 light hazard, ordinary hazard, Group 1, ordinary hazard, Group 2, ordinary hazard, Group 3, or extra hazard occupancy requirements as indicated on the drawings.
- C. Determine volume and pressure of incoming water supply from water flow test data.
- D. Interface system with building fire and smoke alarm system.
- E. Provide fire department connections as indicated on Drawings.

1.3 SUBMITTALS

- A. Submittal Procedures: Refer to Division 1 for Submittal procedures.
- B. Shop Drawings: Indicate layout of finished ceiling areas indicating sprinkler locations coordinated with ceiling installation. Indicate detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
- C. Product Data: Submit data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- D. Samples: Submit two of each style of sprinkler specified.
- E. Design Data: Submit design calculations; signed and sealed by professional engineer

- F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Execution and Closeout Requirements: Refer to Division 1 for Closeout procedures.
- B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
- C. Operation and Maintenance Data: Submit components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 13 standards and State of NC.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.
- C. Design system under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of NC.

1.7 PRE-INSTALLATION MEETINGS

- A. Administrative Requirements Refer to Division 1 for Pre-installation meeting.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Product Requirements: Refer to Division 1 for Product storage and handling requirements.
- B. Store products in shipping containers until installation.
- C. Furnish piping with temporary inlet and outlet caps until installation.

1.9 WARRANTY

- A. Execution and Closeout Requirements: Refer to Division 1 for Product warranties and product bonds.

1.10 EXTRA MATERIALS

- A. Execution and Closeout Requirements: Refer to Division 1 for Spare parts and maintenance products.
- B. Furnish extra sprinklers under provisions of NFPA 13.
- C. Furnish suitable wrenches for each sprinkler type.
- D. Furnish metal storage cabinet in location designated by Authority Having Jurisdiction.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Manufacturers:
 - 1. Reliable Sprinkler Company.
 - 2. Tyco Fire.
 - 3. Viking Corporation.
 - 4. Victaulic.
 - 5. Substitutions: Product Requirements found in Division 1.
- B. Suspended Ceiling Type:
 - 1. Type: Recessed Concealed pendant type with matching screw on escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Enamel, color as selected by Architect.
 - 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- C. Exposed Area Type:
 - 1. Type: Standard upright type with guard as indicated on drawing.
 - 2. Finish: Chrome plated.
 - 3. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- D. Side wall Type:
 - 1. Type: Semi-recessed, Recessed horizontal side wall type with matching screw on escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Enamel, color as selected by Architect.
 - 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.

- E. Guards: Finish to match sprinkler finish.

2.2 PIPING SPECIALTIES

- A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm and electric alarm, with pressure retard chamber and variable pressure trim; with test and drain valve.
- B. Electric Alarm: Electrically operated red enameled gong with pressure alarm switch.
- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.
- D. Fire Department Connections:
 - 1. Type: Flush mounted wall type with brass finish.
 - 2. Outlets: Two-way with City of Wilmington fire department thread size. Threaded dust-cap and chain of matching material and finish.
 - 3. Drain: 3/4 inch automatic drip, connected to drain.
 - 4. Label: "Sprinkler - Fire Department Connection"

2.3 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Electrical Characteristics: In accordance with Section 26 05 03 and as indicated on the drawings.
- B. Controls: Supervisory switches, Water Level Supervisory Switches, Tank Temperature Supervisory Switches, Room Temperature Supervisory Switches.
- C. Disconnect Switch: Factory mount as indicated on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 13.
- B. Install buried shut-off valves in valve box. Furnish post indicator.
- C. Install approved back-flow preventer assembly at sprinkler system water source connection as indicated on the drawings.
- D. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent Siamese connectors to allow full swing of fire department wrench handle.

- E. Locate outside alarm-gong on building wall as indicated on Drawings.
- F. Place pipe runs to minimize obstruction to other work.
- G. Install piping in concealed spaces above finished ceilings.
- H. Center sprinklers in two directions in ceiling tile and install piping offsets.
- I. Hydrostatically test entire system.
- J. Require test be witnessed by Fire Marshall, Authority having jurisdiction, Owner's insurance underwriter, and Architect/Engineer.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Verify signal devices are installed and connected to fire alarm system.

3.3 CLEANING

- A. Execution and Closeout Requirements: Refer to Division 1 for Final cleaning.
- B. Flush entire piping system of foreign matter.

3.4 PROTECTION OF INSTALLED CONSTRUCTION

- A. Execution and Closeout Requirements: Refer to Division 1 for Protecting installed construction.
- B. Protect concealed sprinklers, cover plates, and sprinkler escutcheons from paint. Remove protection after painting. Replace painted sprinklers with new.

END OF SECTION 21 1313

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SECTION 220100**BASIC PLUMBING REQUIREMENTS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 22.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Submittals.
 - 2. Coordination Drawings.
 - 3. Record documents.
 - 4. Maintenance manuals.
 - 5. Rough-ins.
 - 6. Mechanical Installations.
 - 7. Cutting and patching.
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 22 Section "Basic Plumbing Materials and Methods," for materials and methods common to remainder of Division 22, plus general related specifications including:
 - a. Access to plumbing installations.
 - b. Excavation for plumbing installations within the building boundaries, and from building to utilities connections.

1.3 SUBMITTALS

- A. General: Follow the procedures specified in Division 1.
- B. Increase, by the quantity listed below, the number of plumbing related shop drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Mechanical Consulting Engineer.

1. Product Data: 1 additional copy of each item.
 2. Samples: 1 addition as set.
- C. Additional copies may be required by individual sections of these Specifications.

1.4 RECORD DOCUMENTS

- A. Prepare record documents that indicate the following installed conditions:
1. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, water hammer arresters, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 4. Contract Modifications, actual equipment and materials installed.

1.5 MAINTENANCE MANUALS

- A. Prepare maintenance manuals and include the following information for equipment items. **No faxed copies of any kind will be allowed in maintenance manuals, all copies shall be original.**
1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 4. Servicing instructions and lubrication charts and schedules.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - EXECUTION**2.1 ROUGH-IN**

- A. Verify final locations for rough-in with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to other equipment specifications in Divisions for rough-in requirements.

2.2 PLUMBING INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of plumbing systems, materials, and equipment. Comply with the following requirements.
 - 1. Coordinate plumbing systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for plumbing installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations. Provide required connection for each service.
 - 8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
 - 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 - 10. Install plumbing equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
 - 11. Install systems, materials, and equipment giving right-of-way priority to systems requires to be installed at a specific slope.

END OF SECTION 220100

SECTION 220501**BASIC PLUMBING MATERIALS AND METHODS****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following basic plumbing materials and methods to complement other Division 22 Sections:
1. Piping materials and installation instructions common to most piping systems.
 2. Grout.
 3. Equipment installation requirements common to equipment sections.
 4. Painting and finishing.
 5. Concrete equipment base construction requirements.
 6. Supports and anchorages.

1.2 DEFINITIONS

- A. Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.
- B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 QUALITY ASSURANCE

- A. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting plumbing and electrical services, circuit breakers, and conduit sizes are appropriately modified. No additional costs will be approved for these increases, if

larger equipment is approved. If minimum energy ratings or efficiencies are specified, equipment shall comply with design and commissioning requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes 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. Protect stored plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- C. Protect stored piping and tubing from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.
- D. Protect stored flanges, fittings, and piping specialties from moisture and dirt.

1.5 COORDINATION

- A. Coordinate plumbing equipment installation with other building components.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.
- E. Coordinate connection of electrical services.
- F. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
- G. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.
- H. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Solder Filler Metals: ASTM B 32, Alloy Sn95 or Alloy Sn94, tin (approximately 95 percent) and silver (approximately 5 percent) having 0.10 percent lead content. Use water-flushable flux according to ASTM B 813.

2.3 DIELECTRIC FITTINGS

- A. Description: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion..
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.4 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Stainless steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

- A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.6 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.

2.7 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space for ceiling panel removal.
- F. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- G. Install piping at indicated slopes.

- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation plus 1-inch clearance around insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install couplings according to manufacturer's printed instructions.
- M. Install escutcheons for penetrations of concrete and masonry walls, wall board partitions, suspended ceilings, and floors according to the following:
 - 1. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish. Use concrete and masonry walls, wall board partitions, and suspended ceilings.
 - 2. Insulated Piping: Cast-brass, with concealed hinge, spring clips, and chrome-plated finish.
 - 3. Uninsulated Piping at Wall and Floor Penetrations: One-piece, cast-brass type with polished chrome-plated finish and set screw or spring clips.
 - 4. Piping in Equipment Rooms: Cast brass type with set screw or spring clips.
 - 5. Uninsulated Piping at Floor Penetrations in Equipment Rooms: One-piece, cast iron floor-plate type.
- N. Sleeves are not required for core-drilled holes.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - 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 space outside of sleeve fittings with grout.
 - 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section "Joint Sealants" for materials and installation.
- Q. Above Grade Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

- R. Below Grade, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section "Through-Penetration Firestop Systems" for materials.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Construct joints according to AWS "Soldering Manual", Chapter 22 "The Soldering of Pipe and Tube".
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads 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. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - 4. Align threads at point of assembly.
 - 5. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.

3.3 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install plumbing fixtures and equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install plumbing fixtures and equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.
- C. Install plumbing fixtures and equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing fixtures and equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Install plumbing fixtures and equipment with the proper clearness to meet and code authorities having jurisdiction.

3.5 PAINTING

- A. Painting of plumbing systems, equipment, and components is specified in Section "Painting".
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.

- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 220501

SECTION 220519
PLUMBING GAUGES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes gauges for plumbing systems.

1.2 SUBMITTALS

- A. Product Data: Include scale range, ratings, and calibrated performance curves for each gauge, fitting, specialty, and accessory specified.
- B. Product Certificates: Signed by manufacturers of gauges certifying accuracies under specified operating conditions and compliance with specified requirements.

1.3 QUALITY ASSURANCE

- A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation gauges.
- B. Design Criteria: The Contract Documents indicate types, sizes, capacities, ranges, profiles, and connections, of gauges and are based on the specific manufacturer types and models indicated. Gauges having equal performance characteristics by other manufacturers may be considered, provided that deviations do not change the design concept or intended performance as judged by the Engineer. The burden of proof for equality of gauges is on the proposer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Liquid-in-Glass Thermometers:
 - a. Marsh Bellofram
 - b. Marshalltown Instruments, Inc.
 - c. Trerice: H. O. Trerice Co.

- d. Weiss Instruments, Inc.
 - e. Weksler Instruments
- 2. Pressure Gauges:
 - a. AMETEK, Inc.; U.S. Gauge Div.
 - b. Dresser Industries, Inc.; Instrument Div.; Ashcroft Commercial Sales Operation.
 - c. Marsh Bellofram.
 - d. Marshalltown Instruments, Inc.
 - e. Trerice: H. O. Trerice Co.
 - f. Weiss Instruments, Inc.
 - g. Weksler Instruments.
 - h. WIKA Instruments Corp.
- 3. Test Plugs:
 - a. Flow Design, Inc.
 - b. MG Piping Products Co.
 - c. National Meter.
 - d. Peterson Equipment Co., Inc.
 - e. Sisco Manufacturing Co.
 - f. Trerice: H. O. Trerice Co.
 - g. Watts Industries, Inc.; Water Products Div.

2.2 THERMOMETERS, GENERAL

- A. Scale Range: Temperature ranges for services listed are as follows:
 - 1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale.
 - 2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.
- B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

- A. Description: ASTM E 1.
- B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, 9 inches long.
- C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
- D. Tube: Red reading, mercury filled with magnifying lens.
- E. Scale: Satin-faced nonreflective aluminum with permanently etched markings.

- F. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 THERMOMETER WELLS

- A. Description: Fitting with protective well for installation in threaded pipe fitting to hold test thermometer.
 - 1. Material: Brass, for use in copper piping.
 - 2. Material: Stainless steel, for use in steel piping.
 - 3. Extension-Neck for Insulated Piping: Nominal thickness of 2 inches, but not less than thickness of insulation.
 - 4. Insertion Length: To extend to center of pipe.
 - 5. Cap: Threaded cap nut, with chain permanently fastened to well and cap.
 - 6. Pressure Rating: Not less than piping system design pressure.

2.5 PRESSURE GAUGES

- A. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.
- B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch-diameter, glass lens.
- C. Connector: Brass, NPS 1/4.
- D. Scale: White-coated aluminum with permanently etched markings.
- E. Accuracy: Grade A, plus or minus 1 percent of middle 50 percent of scale.
- F. Range: Comply with the following:
 - 1. Fluids under Pressure: Two times the operating pressure.

2.6 PRESSURE-GAUGE FITTINGS

- A. Valves: NPS 1/4 brass or stainless-steel needle type.
- B. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

2.7 TEST PLUGS

- A. Description: Nickel-plated, brass-body test plug in NPS 1/2 fitting.
- B. Body: Length as required to extend beyond insulation.
- C. Pressure Rating: 500 psig minimum.

- D. Core Inserts: Two self-sealing valves, suitable for inserting 1/8-inch OD probe from dial-type thermometer or pressure gauge.
- E. Core Material for Air, Water, Oil, and Gas: 20 to 200 deg F, chlorosulfonated polyethylene synthetic rubber.
- F. Core Material for Air and Water: Minus 30 to plus 275 deg F, ethylene-propylene-diene terpolymer rubber.
- G. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.
- H. Test Kit: Pressure gauge and adapter with probe, two bimetal dial thermometers, and carrying case.
 - 1. Pressure Gauge and Thermometer Ranges: Approximately two times the system's operating conditions.

PART 3 - EXECUTION

3.1 GAUGE INSTALLATION, GENERAL

- A. Install gauges and accessories according to manufacturer's written instructions for applications where used.

3.2 THERMOMETER INSTALLATION

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install in the following locations:
 - 1. At outlet of each water heater.
 - 2. At outlet of mixing valve.

3.3 PRESSURE-GAUGE INSTALLATION

- A. Install pressure gauges in piping tees with pressure-gauge valve located on pipe at most readable position.
- B. Install pressure gauges in the following locations and elsewhere as indicated:
 - 1. Building water-service entrance in vertical riser.
 - 2. On inlet and outlet of hot water recirculation pump.
- C. Install pressure-gauge needle valve and snubber in piping to pressure gauges.

3.4 TEST PLUG INSTALLATION

- A. Install test plugs in piping tees where indicated, located on pipe at most readable position. Secure cap.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Install gauges adjacent to machines and equipment to allow servicing and maintenance.

3.6 ADJUSTING AND CLEANING

- A. Adjust faces of meters and gauges to proper angle for best visibility.
- B. Clean windows of meters and gauges and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 220519

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SECTION 220523**PLUMBING VALVES****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes general duty valves common to several plumbing piping systems.

1.2 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.
- C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.3 QUALITY ASSURANCE

- A. Single-Source Responsibility: Comply with the requirements specified in Division 1 Section "Materials and Equipment," under "Source Limitations" Paragraph.
- B. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.
- C. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. Block check valves in either closed or open position.

- B. Use the following precautions during storage:
1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
 2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ball Valves, 1 inch and smaller:
 - a. Conbraco Industries, Inc.; Apollo Division.
 - b. Crane Company; Valves and Fitting Division.
 - c. Grinnell Corp
 - d. Jamesbury
 - e. Jenkins
 - f. Lunkheimer/Cincinnati Valve Co.
 - g. Metraflex
 - h. Powell
 - i. Stockham Valves & Fittings, Inc.
 - j. Watts
 2. Ball Valves, 1-1/4 inch to 4 inch:
 - a. Conbraco Industries, Inc.; Apollo Division.
 - b. Grinnell Corp
 - c. Powell
 - d. Stockham Valves & Fittings, Inc.
 - e. Watts
 3. Swing Check Valves:
 - a. Crane Company; Valves and Fitting Division
 - b. Grinnell
 - c. Hammond Valve Corporation.
 - d. Jenkins
 - e. Lunkheimer/Cincinnati Valve Co.
 - f. Milwaukee Valve Company, Inc.
 - g. Powell
 - h. Stockham Valves & Fittings, Inc.

2.2 BASIC, COMMON VALVE FEATURES

- A. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.
- B. Sizes: Same size as upstream pipe, unless otherwise indicated.
- C. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
- D. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.
- E. End Connections: As indicated in the valve specifications
 - 1. Threads: Comply with ASME B1.20.1.
 - 2. Solder Joint: Comply with ASME B16.18.
 - a. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for check valves; below 421 deg F for ball valves.

2.3 BALL VALVES

- A. Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, full port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vinyl-covered steel handle. Provide solder ends.
- B. Ball Valves, 1-1/4-Inch to 4-Inch: Rated for 150 psi saturated steam pressure, 400 psi WOG pressure; 3-piece construction; with bronze body conforming to ASTM B 62, full port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for 2" and smaller, threaded ends for 2 1/2" and larger.

2.4 CHECK VALVES

- A. Swing Check Valves: MSS SP-80; Class 125, 200-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections Provide valves capable of being reground while the valve remains in the line. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available. Install check valves in hot and cold water supply piping to all mop sinks.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to valve installation, examine piping system for compliance with requirements for installation tolerances, cleanliness, freedom from foreign materials and proper alignment.
- B. 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.
- C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation. Following examination, return the valve closure member to the shipping position
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Replace defective valves with new valves.

3.2 INSTALLATION

- A. Install valves as indicated, according to manufacturer's written instructions.
- B. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.
- D. Locate valves for easy access and provide separate support where necessary. Where possible, locate valves at a maximum of 6' - 0" above finished floor in mechanical spaces.
- E. Install valves in horizontal piping with stem at or above the center of the pipe.
- F. Install valves in a position to allow full stem movement.
- G. Installation of Check Valves: Install for proper direction of flow as follows:
 - 1. Swing Check Valves: Horizontal position with hinge pin level.

3.3 SOLDERED CONNECTIONS

- A. Cut tube square and to exact lengths.
- B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.
- C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.
- D. Remove the cap and disc holder of swing check valves having composition discs.

- E. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.
- F. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 THREADED CONNECTIONS

- A. Note the 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.
- B. Align threads at point of assembly.
- C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.
- D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.5 FIELD QUALITY CONTROL

- A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.6 CLEANING

- A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

END OF SECTION 220523

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SECTION 220529**PLUMBING HANGERS AND SUPPORTS****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes hangers and supports for plumbing system piping and equipment.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide hangers and supports that are listed and labeled as defined in NFPA 70, Article 100.
 - 1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS**2.1 MANUFACTURERS****2.2 MANUFACTURED UNITS**

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components.
 - 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.
 1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

2.3 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex-head, track bolts and nuts.
- C. Washers: ASTM F 844, steel, plain, flat washers.
- D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.
 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 2. Properties: Non-staining, noncorrosive, and nongaseous.
 3. Design Mix: 5000-psi, 28-day compressive strength.
 4. Water: Potable
 5. Packaging: Premixed and factory-packaged.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

- B. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- C. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.
- D. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
- E. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. 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.
- H. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- I. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- J. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9.
 - 2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
5. Pipes NPS 2 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. 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 above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section "Painting."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529

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SECTION 220553**PLUMBING IDENTIFICATION****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following plumbing identification materials, devices and their installation:

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Valve Schedules: Submit valve schedules for each piping system. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification. Mark valves intended for emergency shutoff and similar special uses. Furnish extra copies (in addition to mounted copies) for Maintenance Manuals.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.4 COORDINATION

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

PART 2 - PRODUCTS**2.1 IDENTIFICATION DEVICES AND LABELS**

- A. General: Products specified are manufacturer's standard products of categories and types required for each application as referenced in other Division 22 Sections. Where

more than single type is specified for listed application, selection is Installer's option, but provide single selection for each product category.

- B. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data. Submit completion date and warranty information.
 - 2. Location: Accessible and visible.
- C. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- D. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- E. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch-thick brass.
- F. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.
- G. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
 - 1. Frame: Extruded aluminum.
 - 2. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.
- H. Access Panel Markers: 1/16-inch-thick engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed valve. Provide 1/8-inch center hole for attachment.
- I. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.
 - 1. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service
- J. Paint and color code all exposed piping in mechanical and boiler rooms. Piping shall have flow arrows and labels located at 10 foot intervals at all turns and at each floor or wall penetration and shall be color coded as follows:
 - 1. Cold Water - Dark Blue
 - 2. Hot Water - Dark Red
 - 3. Hot Water Recirculation - Dark Red

4. Gas Lines - Yellow

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of plumbing equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
 1. Main control and operating valves, including safety devices
 2. Gauges, thermometers, and similar units
 3. Strainers and filters.
- B. Optional Sign Types: Stenciled signs may be provided instead of engraved plastic, at Installer's option, ONLY where lettering larger than 1-inch high is needed for proper identification because of distance from normal location of required identification.
 1. Lettering Size: Minimum 1/4 inch for name of unit where viewing distance is less than 2 feet, 1/2 inch for distances up to 6 feet, and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.
 2. Terms on Signs: Indicate operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations

3.2 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
 1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
- B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 25 feet along each run.
 7. On piping above removable acoustical ceilings.

3.3 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose bibbs; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 2 inches, round.
 - b. Hot Water: 2 inches, round
 - 2. Install ceiling panel access markers for valves above ceiling. Attach marker to ceiling grid at all locations where valves are located above ceiling.

3.4 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.5 ADJUSTING

- A. Relocate plumbing identification materials and devices that have become visually blocked by other work.

3.6 CLEANING

- A. Clean faces of plumbing identification devices and glass frames of valve schedules.

END OF SECTION 220553

SECTION 220700**PLUMBING INSULATION****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
 - 2. Insulation application at pipe expansion joints for each type of insulation.
 - 3. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 4. Removable insulation at piping specialties and equipment connections.
 - 5. Application of field-applied jackets.
- C. Samples: For each type of insulation and jacket. Identify each Sample, describing product and intended use. Submit Samples in the following sizes:
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
- D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.
- E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.3 QUALITY ASSURANCE

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

- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Plumbing Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for insulation application.
- C. Coordinate installation and testing of steam or electric heat tracing.

1.6 SCHEDULING

- A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Glass-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Glass-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 - 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 - 2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 - 3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 - 4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 - 5. Glass-Fiber Insulating Cements: Comply with ASTM C 195.
 - 6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 - 7. Glass-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- B. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

- A. Canvas Jacket: 8 ounce.

2.4 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
1. Pull jacket tight and smooth.
 2. Circumferential Joints: Cover with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.
- P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retarder mastic.
 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal metal jacket to roof flashing with vapor-retarder mastic.
- Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
1. Firestopping and fire-resistive joint sealers are specified in Section "Firestopping."

- T. Floor Penetrations: Apply insulation continuously through floor assembly.
 - 1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 GLASS-FIBER INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 - 1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
 - 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
 - 3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
 - 4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
- B. Apply insulation to fittings and elbows as follows:
 - 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - 2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
 - 3. Cover fittings with standard PVC fitting covers.
- C. Apply insulation to valves and specialties as follows:
 - 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - 2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
 - 3. Apply insulation to flanges as specified for flange insulation application.
 - 4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
 - 5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FIELD-APPLIED JACKET APPLICATION

- A. Apply canvas jacket where indicated, with 2-inch overlap at longitudinal seams and end joints

3.6 FINISHES

- A. Paint finished insulation as specified in Section "Painting".
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work

3.7 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - 1. Flexible connectors.
 - 2. Vibration-control devices.
 - 3. Fire-suppression piping.
 - 4. Drainage piping located in crawl spaces, unless otherwise indicated.
 - 5. Below-grade piping, unless otherwise indicated.
 - 6. Chrome-plated pipes and fittings, unless potential for personnel injury.
 - 7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.8 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 - 1. Inspect fittings and valves randomly selected by Government.
 - 2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
 - 3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.9 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.10 INTERIOR INSULATION APPLICATION SCHEDULE

- A. Service: Domestic hot, cold and recirculated hot water piping and horizontal roof drain piping, including roof drain sump, in exposed spaces.
 - 1. Operating Temperature: 35 to 140 deg F.
 - 2. Insulation Material: Glass-fiber, with jacket.
 - 3. Insulation Thickness: Apply the following insulation thicknesses:
 - a. All sizes: 1"
 - 4. Field-Applied Jacket: Canvas.
 - 5. Vapor Retarder Required: Yes.
 - 6. Finish: Painted.
- B. Service: Domestic hot, cold and recirculated hot water piping and horizontal roof drain piping, including roof drain sump, in concealed spaces
 - 1. Operating Temperature: 35 to 140 deg F.
 - 2. Insulation Material: Glass fiber.
 - 3. Insulation Thickness: Apply the following insulation thicknesses:
 - a. All sizes: 1"
 - 4. Field-Applied Jacket: None.
 - 5. Vapor Retarder Required: Yes.
 - 6. Finish: None.
- C. Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled.
 - 1. Operating Temperature: 35 to 120 deg F.
 - 2. Insulation: McGuire Prowrap PW2000 or equal.

END OF SECTION 220700

SECTION 221116**DOMESTIC WATER PIPING****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes domestic water piping from locations indicated to fixtures and equipment inside the building.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Service Piping: 160 psig.
 - 2. Domestic Water Distribution Piping: 150 psig.

1.3 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in "Cleaning" Article in Part 3.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS**2.1 PIPING MATERIALS**

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

- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- C. Transition Couplings for Underground Pressure Piping: AWWA C219, metal, sleeve-type coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 COPPER TUBING

- A. Soft Copper Tube: ASTM B 88, Types K, water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. 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.
- B. Hard Copper Tube: ASTM B 88, Types L, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. 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.

2.3 VALVES

- A. Refer to Division 22 Section "Plumbing Valves" for general-duty valves.
- B. Refer to Division 22 Section "Plumbing Specialties" for balancing and drain valves.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Underground Domestic Water Service Piping: Use the following piping materials for each size range:

1. NPS 4 and Smaller: Soft copper tube, Type K; copper pressure fittings; and silver soldered joints.
- C. Aboveground Domestic Exposed Water Piping in Occupied Areas: Use the following piping materials for each size range:
1. NPS 4 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.

3.3 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Shutoff Duty: Use ball valves.
 2. Throttling Duty: Use ball valves.
 3. Drain Duty: Hose-end drain valves.

3.4 PIPING INSTALLATION

- A. Refer to Section "Water Distribution" for site water distribution and service piping.
- B. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping installation.
- C. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.
- D. Install underground copper tubing according to CDA's "Copper Tube Handbook."
- E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for sleeves and mechanical sleeve seals.
- F. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for wall penetration systems.
- G. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside building at each domestic water service. Refer to Division 22 Section "Plumbing Gages" for pressure gages, and to Division 22 Section "Plumbing Specialties" for drain valves and strainers.
- H. Install aboveground domestic water piping level and plumb.
- I. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.

- J. Perform the following steps 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. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
- K. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
- L. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.5 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping joint construction.
- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.6 VALVE INSTALLATION

- A. Install sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment. Use ball valves for piping NPS 4 and smaller.
- B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops. Use ball valves for piping NPS 4 and smaller.
- C. Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install hose-end drain valves at low points in water mains, risers, and branches.
 - 2. Install stop-and-waste drain valves where indicated.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Plumbing Hangers and Supports" for pipe hanger and support devices. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Plumbing Hangers and Supports."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.

3.8 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.
- C. Connect domestic water piping to exterior water service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to service piping with shutoff valve, and extend and connect to the following:
1. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
 3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.9 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:

1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Cap and subject piping to static water pressure of 100 psig. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
4. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.10 CLEANING

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

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

- c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 COMMISSIONING

- A. Fill water systems. Check compression tanks to determine that they are not air bound and that system is completely full of water.
- B. Before operating systems, perform these steps:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to full open position.
 - 3. Open throttling valves to proper setting.
 - 4. Remove plugs used during testing of piping systems and plugs used for temporary sealing of piping during installation.
- C. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
- D. Check plumbing specialties and verify proper settings, adjustments, and operation.
- E. Energize equipment and verify proper operation.

END OF SECTION 221116

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SECTION 221316**SOIL, WASTE, AND VENT PIPING****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes storm drainage piping and soil, waste and vent piping inside the building and to locations indicated.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.3 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Shop Drawings: For controlled-flow storm drainage system, include calculations, plans, and details.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS**2.1 PIPING MATERIALS**

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

- B. Flexible Transition Couplings for Underground Nonpressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

2.2 CAST-IRON SOIL PIPING

- A. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral center pipe stop.
 - a. Heavy-Duty, Cast-Iron Couplings: ASTM A 48, 2-piece, cast-iron housing; stainless-steel bolts and nuts; and sleeve.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
- C. Aboveground, Soil, Waste, and Vent Piping: Use the following piping materials for each size range:
 - 1. NPS 2 to NPS 6: Hubless, cast-iron soil piping; gaskets; and one of the following:
 - a. Couplings: Heavy-Duty, cast-iron.
- D. Underground, Soil, Waste, and Vent Piping: Use the following piping materials for each size range:
 - 1. NPS 2 to NPS 6: Hub and Spigot fittings with neoprene gaskets.

3.3 PIPING INSTALLATION

- A. Refer to Section "Sanitary Sewerage" for Project-site sanitary sewer piping.
- B. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping installation.

- C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for sleeves and mechanical sleeve seals.
- E. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for wall penetration systems.
- F. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- G. Install engineered soil and waste drainage and vent piping systems in locations indicated and as follows:
 - 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 - 2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
- H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- I. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- J. Install drainage piping at the following minimum slopes, unless otherwise indicated:
 - 1. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 2. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 2 and smaller; 1 percent downward in direction of flow for piping NPS 3 and larger.
 - 3. Horizontal Sanitary Drainage Piping: 1 percent downward in direction of flow.
 - 4. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- K. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- L. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping joint construction.
- B. Cast-iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Hubless Joints: Make with rubber gasket and sleeve or clamp.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Plumbing Hangers and Supports" for pipe hanger and support devices. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Plumbing Hangers and Supports."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install supports for vertical cast-iron soil piping every 15 feet .
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6: 60 inches with 3/4-inch rod.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Specialties."
 - 4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.7 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and

watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING

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

END OF SECTION 221316

SECTION 221319**PLUMBING SPECIALTIES****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes plumbing specialties for water distribution systems; soil, waste, and vent systems; and storm drainage systems.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Piping, Below Grade: 160 psig.
 - 2. Domestic Water Piping, Above Grade: 150 psig.
 - 3. Soil, Waste and Vent Piping: 10-foot head of water.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections
- B. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:
 - 1. Backflow preventers.
 - 2. Strainers.
 - 3. Water hammer arresters and trap seal primer valves and systems.
 - 4. Drain valves, hose bibbs, and hydrants.
 - 5. Cleanouts, floor drains, and roof drains.
 - 6. Sleeve penetration systems.
- C. Shop Drawings: Diagram power, signal, and control wiring.
- D. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:
 - 1. Backflow preventers.
 - 2. Trap seal primer valves and systems.
 - 3. Hydrants.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.
- E. Electrical Component Standard: NFPA 70, "National Electrical Code."
- F. Design Concept: The Drawings indicate capacities, sizes, and dimensional requirements of system components. Components having equal performance characteristics that deviate from the indicated size and dimensions may be considered, provided deviations do not change the design concept or intended performance. The burden of proof for equality of products is on the Contractor.

1.5 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Operating Key Handles: Equal to 50 percent of amount installed for each key-operated hose bibb and hydrant installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Products: Subject to compliance with requirements, provide one of the products specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 STRAINERS

- A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch round perforations, unless otherwise indicated.
 - 1. Pressure Rating: 125-psig minimum steam working pressure, unless otherwise indicated.
 - 2. NPS 2 and Smaller: Bronze body, with female threaded ends.
 - 3. NPS 2-1/2 and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.
 - 4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.
 - a. Drain: Pipe plug.

2.3 OUTLET BOXES

- A. Manufacturers:
 - 1. Acorn Engineering Company.
 - 2. Gray, Guy Manufacturing Co., Inc.
 - 3. IPS Corporation.
 - 4. LSP Products Group.
 - 5. Oatey.
 - 6. Plastic Oddities, Inc.
 - 7. Symmons Industries, Inc.
- B. General: Recessed-mounting outlet boxes with supply fittings complying with ASME A112.18.1M. Include box with faceplate, services indicated for equipment connections, and wood-blocking reinforcement.
- C. Icemaker Outlet Boxes: With hose connection and the following:
 - 1. Supply Fitting: NPS 1/2: gate or ball valve and NPS 1/2 copper, water tubing.
- D. Reinforcement: 2-by-4-inch fire-retardant-treated-wood blocking between studs.

2.4 KEY-OPERATION HYDRANTS

- A. Available Manufacturers:
- B. Manufacturers:
 - 1. Josam Co.
 - 2. Smith, Jay R. Mfg. Co.
 - 3. Tyler Pipe; Wade Div.
 - 4. Woodford Manufacturing Co.
 - 5. Zurn Industries, Inc.
 - 6. Mifab
- C. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig.

1. Inlet: NPS 3/4 or NPS 1 threaded or solder joint.
 2. Outlet: ASME B1.20.7, garden-hose threads.
 3. Operating Keys: One with each key-operation hydrant.
- D. Nonfreeze Exposed-Outlet Wall Hydrants: ASSE 1019, self-drainable with integral nonremovable hose-connection vacuum breaker, casing and operating rod to match wall thickness, projecting outlet, and wall clamp.
1. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
 2. Nozzle and Wall Plate Finish: Polished chrome plate.

2.5 HOSE BIBBS

- A. Manufacturers:
1. Josam Co.
 2. Smith, Jay R. Mfg. Co.
 3. Tyler Pipe; Wade Div.
 4. Woodford Manufacturing Co.
 5. Zurn Industries, Inc.
 6. Mifab
- B. Description: Bronze body, with renewable composition disc, 1/2- or 3/4-inch threaded or solder-joint inlet. Provide ASME B1.20.7 garden-hose threads on outlet and integral or field-installed, nonremovable, drainable, hose-connection vacuum breaker.
1. Finish: Rough brass.
 2. Operation: Operating key (handle). Provide 1 operating key.

2.6 DRAIN VALVES

- A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 ball valve, rated for 400-psig minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.
1. Inlet: Threaded or solder joint.
 2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.
- B. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 side drain outlet and cap.

2.7 MISCELLANEOUS PIPING SPECIALTIES

- A. Piping specialties such as escutcheons, dielectric fittings, sleeves, and sleeve seals are specified in Division 22 Section "Basic Plumbing Materials and Methods."

- B. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.
 - 1. Manufacturers:
 - a. Josam Co.
 - b. Precision Plumbing Products, Inc.
 - c. Zurn Industries, Inc.; Hydromechanics Div.
 - d. Mifab
- C. Roof Flashing Assemblies: Manufactured assembly made of [4-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 8 inches from pipe with galvanized steel boot reinforcement, and counterflashing fitting.
 - 1. Open-Top Vent Cap: Without cap.
- D. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.
- E. Firestop Penetration Assemblies: Shall meet Underwriter's laboratories fire resistance directory, Volume II, latest edition.
- F. Expansion Joints: ASME A112.21.2M, assembly with cast-iron body with bronze sleeve, packing gland, and packing; of size and end types corresponding to connected piping.

2.8 CLEANOUTS

- A. Manufacturers:
 - 1. Ancon, Inc.
 - 2. Josam Co..
 - 3. Smith, Jay R. Mfg. Co.
 - 4. Tyler Pipe; Wade Div.
 - 5. Zurn Industries, Inc.; Hydromechanics Div.
 - 6. Mifab
- B. General: Size cleanouts as indicated on drawings, or where not indicated, same size as connected drainage piping. Cleanouts larger than 4 inches are not required except where indicated.
- C. Cleanouts: ASME A112.36.2M, cast-iron body with straight threads and gasket seal or taper threads for plug, flashing flange and clamping ring, and a brass closure plug. Cleanouts for installation in floors not having membrane waterproofing may be furnished without clamping ring.

2.9 FLOOR DRAINS

- A. Manufacturers:
 - 1. Watts Drainage Products.
 - 2. Josam Co..
 - 3. Smith, Jay R. Mfg. Co.
 - 4. Tyler Pipe; Wade Div.
 - 5. Zurn Industries, Inc.; Hydromechanics Div.
 - 6. Mifab
- B. General: Size outlets as indicated on the drawings.
- C. Floor Drains: ASME A112.21.1M, cast-iron body, with seepage flange and clamping device. Floor drains for installation in floors not having membrane waterproofing may have seepage flange without clamping device. Floor drains for use as area drains in exterior slab on grade may be furnished with anchor flange instead of seepage flange and clamping device.
- D. Deep Seal Traps: Cast iron or bronze, with inlet and outlet matching connected piping, cleanout where indicated, and trap seal primer valve connection where indicated.
 - 1. 2-Inch Size: 4-inch-minimum water seal
 - 2. 2-1/2 Inches and Larger: 5-inch-minimum water seal.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- C. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.
- D. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

- E. Install trap seal primer valves 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.
- F. Install expansion joints on vertical risers, stacks, and conductors if indicated.
- G. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- H. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
- I. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.
- J. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
- K. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.
- L. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- M. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

- N. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
- O. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- P. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.
- Q. Install individual shutoff valve in each water supply to plumbing specialties. Use ball valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 22 Section "Plumbing Valves" for general-duty ball and check valves.
- R. Install air vents at piping high points. Include ball valve in inlet and drain piping from outlet to floor drain.
- S. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- T. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect plumbing specialties to piping specified in other Division 22 Sections.
- D. Ground equipment.
- E. 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.
- F. Connect plumbing specialties and devices that require power according to Division 26 Sections.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4-lb/sq. ft., 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.

- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 COMMISSIONING

- A. Preparation: Perform the following checks before start-up:
 - 1. Systems tests are complete.
 - 2. Damaged and defective specialties and accessories have been replaced or repaired.
 - 3. There is clear space for servicing of specialties.
- B. Before operating systems, perform these steps:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open valves to full open position.
 - 3. Remove and clean strainers.
 - 4. Verify drainage and vent piping are clear of obstructions. Flush with water until clear.

3.5 PROTECTION

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

3.6 ADJUSTING

- A. Adjust operation and correct deficiencies discovered during commissioning.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Government's maintenance personnel to adjust, operate, and maintain interceptors.

END OF SECTION 221319

SECTION 221416**FUEL GAS PIPING****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes fuel gas piping, specialties, and accessories within the building.
- B. Refer to Section 230548 for Vibration, Wind, and Seismic Controls.

1.2 PROJECT CONDITIONS

- A. Gas System Pressures: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2.0 psig, and is reduced to secondary pressure of 0.5 psig or less.
- B. Design values of fuel gas supplied for these systems are as follows:
 - 1. Nominal Heating Value: 1000 Btu/cu. ft.
 - 2. Nominal Specific Gravity: 0.6.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Corrugated, stainless-steel tubing systems. Include associated components.
 - 2. Specialty valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Include pressure rating, capacity, and settings of selected models.
- B. Shop Drawings: For fuel gas piping. Include plans and attachments to other Work.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- B. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."
- C. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.
- D. IAS Standard: Provide components listed in IAS's "Directory of A. G. A. and C. G. A Certified Appliances and Accessories" if specified to be IAS listed.
- E. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify fuel gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Gas Stops, NPS 2 and Smaller:
 - a. Hammond Valve
 - b. Jomar International, Ltd.
 - c. Maxitrol
 - d. McDonald: A. Y. McDonald Mfg. Co.
 - e. Milwaukee Valve Co., Inc.
 - f. Mueller Co.; Mueller Gas Products Div.
 - g. National Meter
 - 2. Gas Valves, NPS 2 and Smaller:
 - a. Conbraco Industries, Inc.; Apollo Div.

- b. Huber
 - c. McDonald: A. Y. McDonald Mfg. Co.
 - d. Milliken Valve Co.
 - e. Milwaukee Valve Co., Inc.
 - f. Mueller Co.; Mueller Gas Products Div.
 - g. National Meter
 - h. Nordstrom Valves
 - i. Olson Technologies
- 3. Gas Valves, NPS 2-1/2 and Larger
 - a. Huber
 - b. Milliken Valve Co.
 - c. Mueller
 - d. Nordstrom Valves
 - e. Olson Technologies
 - f. Xomox Corp.

2.2 PIPING MATERIALS

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

2.3 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

- A. Steel Pipe: ASTM A 53; Type E or S; Grade B; Schedule 40; black.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
 - 2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
 - 3. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
 - 4. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
 - 5. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
 - 6. Joint Compound and Tape: Suitable for natural gas.
 - 7. Steel Flanges and Flanged Fittings: ASME B16.5.
 - 8. Gasket Material: Thickness, material, and type suitable for natural gas.
- B. Common Joining Materials: Refer to Division 22 Section "Basic Plumbing Materials and Methods" for joining materials not in this Section.
- C. Corrugated Stainless Steel Gas Tubing:
 - 1. Tubing: ASTM A240 Type 304 321 Stainless Steel
 - 2. Jacket: UV resistant Polyethylene complying with requirements of ASTM E84 Index for Flame and Smoke.

2.4 PROTECTIVE COATING

- A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in underground applications.

2.5 PIPING SPECIALTIES

- A. Flexible Connectors: ANSI Z21.24, copper alloy.
- B. Quick-Disconnect Devices: ANSI Z21.41, convenience outlets and matching plug connector.

2.6 SPECIALTY VALVES

- A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
- B. Valves, NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
- C. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig minimum pressure rating.
- D. Gas Valves, NPS 2 and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating.
 - 1. Tamperproof Feature: Include design for locking.
- E. Plug Valves, NPS 2-1/2 and Larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig pressure rating.
 - 1. Tamperproof Feature: Include design for locking.

2.7 CONCRETE BASES

- A. Description: Precast, reinforced concrete base, made of 3000-psi-minimum, 28-day compressive strength concrete, and measuring 4 inches thick and 4 inches larger in each dimension than supported item, unless otherwise indicated.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.
- B. Comply with ANSI Z223.1, "Prevention of Accidental Ignition" Paragraph.

3.2 SERVICE ENTRANCE PIPING

- A. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.
 - 1. Natural gas distribution system piping, service pressure regulator, and service meter are by gas company.
- B. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for dielectric fittings.
- C. Install strainer upstream from each earthquake valve. Refer to Division 22 Section "Plumbing Specialties" for strainers.

3.3 CONCRETE BASE INSTALLATION

- A. Locate bases at service meters and service regulators.
- B. Excavate earth and make level beds to support bases. Set bases level with top surface projecting approximately 3 inches above grade.

3.4 PIPING APPLICATIONS

- A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.
- B. Fuel Gas Piping, 0.5 psig or Less: Use the following:
 - 1. NPS 1/2 and Smaller: NPS 3/4 steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 2. NPS 3/4 to 4: Steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 3. Larger Than NPS 4: Steel pipe, steel welding fittings, and welded joints.
- C. Fuel Gas Piping, 0.5 to 2 psig: Use the following:
 - 1. NPS 1/2 and Smaller: NPS 3/4 steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 2. NPS 3/4 to 2: Steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 3. NPS 2-1/2 to NPS 4: Steel pipe, steel welding fittings, and welded joints.

- 4. Larger Than NPS 4: Steel pipe, steel welding fittings, and welded joints.
- D. Underground Fuel Gas Piping: Corrugated stainless steel gas tubing. Encase in containment conduit vented to exterior of the building.
- E. Containment Conduits: Steel pipe, steel welding fittings, and welded joints.

3.5 VALVE APPLICATIONS

- A. Piping Line Valves, NPS 2 and Smaller: Gas valve.
- B. Piping Line Valves, NPS 2-1/2 and Larger: Plug valve or general-duty valve.

3.6 PIPING INSTALLATION

- A. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping installation requirements.
- B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.
 - 1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
 - 2. In Floors: Corrugated stainless steel gas tubing. Piping shall be installed in under ground conduit vented to exterior of the building. Install piping to allow removal of flexible tubing in the future.
 - 3. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.
 - a. Exception: Tubing passing through partitions or walls.
 - 4. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in masonry walls, subject to approval of authorities having jurisdiction.
 - 5. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - a. Exception: Accessible above-ceiling space specified above.
- C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

- D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, unless indicated to be exposed to view.
- E. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.
- F. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- G. Connect branch piping from top or side of horizontal piping.
- H. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
- I. Install corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.
- J. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.
- K. Install pressure gage downstream from each line pressure regulator.
- L. Install flanges on valves, specialties, and equipment having NPS 2-1/2 and larger connections.
- M. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.
- N. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar, epoxy-polyamide paint according to SSPC-Paint 16.

3.7 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Basic Plumbing Materials and Methods" for basic piping joint construction.
- B. Use materials suitable for fuel gas.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Plumbing Hangers and Supports" for pipe hanger and support devices.

3.9 CONNECTIONS

- A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.
- B. Install piping adjacent to appliances to allow service and maintenance.
- C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches of each appliance. Install union downstream from valve.
- D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.
- E. Ground equipment.
 - 1. 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.
 - 2. Do not use gas pipe as grounding electrode.

3.10 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator, and specialty valve.
 - 1. Text: In addition to name of identified unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.11 PAINTING

- A. Use materials and procedures in Section "Painting".

3.12 FIELD QUALITY CONTROL

- A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.
- B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
- C. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.
- E. Verify correct pressure settings for pressure regulators.
- F. Verify that specified piping tests are complete.

3.13 ADJUSTING

- A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 221416

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SECTION 221429 – GRINDER PUMP STATION
(FLYGT TOP PRE-ENGINEERED FIBERGLASS PUMP STATION)

1.1 GENERAL:

- A. The contractor shall provide all materials, equipment and labor necessary to install, test and place into service the TOP pre-engineered fiberglass pump station as shown in the plans and described in this specification. The pre-engineered pump station package, including submersible pumps, pump control, fiberglass pump station, internal piping, accessories and auxiliary equipment shall be supplied by the pump manufacturer.

1.2 REQUIREMENTS:

- A. The TOP pre-engineered fiberglass pump station package shall be capable of handling unscreened sewage, wastewater or stormwater in accordance with the design conditions defined in construction documents and described in this specification.
- B. The fiberglass pump station shall have an integral, hopper-shaped pump station bottom, which is self-cleaning by virtue of its design. The flat surface area shall be minimized to an area that is directly influenced by the pump suction and shall be free of obstacles. The bottom surface area shall have a ratio of 1:4 as it relates to the cross-sectional area of the pump station. The sloping walls of the pump station bottom shall further optimize the self-cleaning features of this station by directing all solids, trash and sludge, normally found in sewage and wastewater, to the suction of the submersible pumps to facilitate removal and effectively clean the bottom.
- C. Furnish and install 2 submersible non-clog wastewater pump(s). Each pump shall be equipped with a 4 HP submersible electric motor, connected for electrical operation as required, with 50 feet of submersible cable (SUBCAB), suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards and have P-MSHA Approval. The pump shall be supplied with a mating cast iron discharge connection and be capable of delivering flows and pressures indicated on the plans. Each pump shall be fitted with lifting chain or stainless steel cable. The working load of the lifting system shall be 50% greater than the pump unit weight.

1.3 PUMPS:

- A. PUMP DESIGN: The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two (stainless steel, galvanizes steel) guide pipes extending from the top of the station to the discharge connection. There shall be no need for personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. **Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable.** No portion

of the pump shall bear directly on the sump floor.

- B. PUMP CONSTRUCTION: Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts or bolts shall be AISI type 304 stainless steel construction. All metal surfaces coming into contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.
1. Sealing design shall incorporate **metal-to-metal contact** between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.
 2. Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.
- C. CABLE ENTRY SEAL: The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by stainless steel washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable. The assembly shall provide ease of changing the cable when necessary using the same entry seal. **The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.**
- D. MOTOR: The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The stator shall be insulated by the trickle impregnation method using Class H monomer-free polyester resin resulting in a winding fill factor of at least 95%. The motor shall be inverter duty rated in accordance with NEMA MG1, Part 31. The stator shall be heat-shrink fitted into the cast iron stator housing. The use of multiple step dip and bake-type stator insulation process is not acceptable. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. The motor shall be designed for continuous duty handling pumped media of 40°C (104°F) and capable of at least 15 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of cast aluminum. Thermal switches set to open at 125°C (260°F) shall be embedded in the stator end coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be

hermetically sealed from the motor by an elastomer compression seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. The motor and the pump shall be produced by the same manufacturer.

The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15. The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 40°C (104°F) ambient and with a temperature rise not to exceed 80°C. A performance chart shall be provided upon request showing curves for torque, current, power factor, input/output kW and efficiency. This chart shall also include data on starting and no-load characteristics.

The power cable shall be sized according to the NEC and ICEA standards and shall be of sufficient length to reach the junction box without the need of any splices. The outer jacket of the cable shall be oil resistant chlorinated polyethylene rubber. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet or greater.

The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out.

- E. MOTOR COOLING SYSTEM: (Pumps with motors up to 10-hp) Motors are sufficiently convection-cooled by the surrounding environment or pumped media.

(Pumps with motors of 12-hp and greater) Motors shall be equipped with an integral motor cooling jacket of either an open type or closed-loop type.

- F. BEARINGS: The pump shaft shall rotate on two bearings. Motor bearings shall be permanently grease lubricated. The upper bearing shall be a single deep groove ball bearing. The lower bearing shall be a two row angular contact bearing to compensate for axial thrust and radial forces. **Single row lower bearings are not acceptable.**

- G. MECHANICAL SEAL: Each pump shall be provided with a tandem mechanical shaft seal system consisting of two totally independent seal assemblies. The seals shall operate in a lubricant reservoir that hydrodynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump and the lubricant chamber, shall contain one stationary and one positively driven rotating corrosion resistant, **tungsten-carbide** ring. The upper, secondary seal unit, located between the lubricant chamber and the motor housing, shall contain one stationary and one positively driven rotating corrosion resistant, **tungsten-carbide** seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor **depend on direction of rotation for sealing**. The position of both mechanical seals shall depend on the shaft. Mounting of the lower mechanical seal on the impeller hub will not be acceptable. For unique applications, other seal face materials shall be available.

The following seal types shall not be considered acceptable nor equal to the dual independent seal specified: shaft seals without positively driven rotating members, or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces. No system requiring a pressure differential to offset pressure and to affect sealing shall be used.

Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and to provide lubricant expansion capacity. The drain and inspection plug, with positive anti-leak seal shall be easily accessible from the outside. The seal system shall not rely upon the pumped media for lubrication. **The motor shall be able to operate non-submerged without damage while pumping under load.**

Seal lubricant shall be non-toxic and FDA Approved.

- H. PUMP SHAFT: Pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T.

The use of stainless steel sleeves will not be considered equal to stainless steel shafts as shaft sleeves only protect the shaft around the lower mechanical seal.

- I. PUMP IMPELLER / VOLUTE FOR M-TYPE GRINDER PUMPS: Each grinder pump shall be a **heavy duty pump** modified to be used as a grinder. Each grinder pump shall contain special cutters to reduce sewage to a fine slurry. The stationary cutter shall consist of **hardened 316 "L" stainless steel** and the rotary cutter shall consist of chrome alloyed cast iron. The cutter materials shall provide maximum corrosion and abrasion resistance. The remaining portion of the grinder pumps, with the exception of seal materials and wet end, shall be similar to the heavy duty pumps used in larger pump stations for daily operation.
- J. IMPELLER: The impeller(s) shall be of grey cast iron, Class 35B, dynamically balanced, single shrouded design having a long throughlet without acute turns. The impellers shall be capable of handling fine slurry from the special cutters. Impeller(s) shall be taper collet fitted and retained with an Allen head bolt. All impellers shall be coated with an acrylic dispersion zinc phosphate primer.
- K. VOLUTE: Pump volute(s) shall be single-piece grey cast iron, Class 35B, non-concentric design with smooth passages large enough to pass any media that may enter the impeller. Minimum inlet and discharge size shall be as specified.
- L. SUMP MIXING VALVE: One pump unit in each TOP pump station shall be equipped with an automatically operating Flygt Mix-flush Valve mounted directly to a machined boss located on the exterior of the pump volute casting that will provide mixing action within the sump at the start of the pumping cycle. The valve shall redirect a portion of the pumped media into the sump to re-suspend solids and grease by the turbulent action of its discharge.

The valve shall be equipped with an adjustable, wear-resistant discharge nozzle that can be used to direct flow within the sump. The valve shall operate by differential pressure across the valve and shall not require any electric or pneumatic power source to operate. The valve shall be suitable for use in Class I, Division 1 hazardous locations.

The valve shall open at the beginning of each pumping cycle and shall automatically close during the pump operation after a pre-set time. A method of adjusting the valve operating time shall be provided.

- M. MOTOR PROTECTION: All stators shall incorporate thermal switches in series to monitor the temperature of each phase winding. The thermal switches shall open at 125°C (260°F), stop the motor and activate an alarm.

A leakage sensor shall be available as an option to detect water in the stator chamber. The Float Leakage Sensor (FLS) is a small float switch used to detect the presence of water in the stator chamber. When activated, the FLS will stop the motor and send an alarm both local and/or remote. USE OF VOLTAGE SENSITIVE SOLID STATE SENSORS AND TRIP TEMPERATURE ABOVE 125°C (260°F) SHALL NOT BE ALLOWED.

The thermal switches and FLS shall be connected to a Mini CAS (Control and Status) monitoring unit. The Mini CAS monitoring unit shall be designed to be mounted in any control panel.

1.4 TOP PRE-ENGINEERED FIBERGLASS PUMP STATION CONSTRUCTION:

- A. The station cylinder shall be affixed to the station bottom such that the assembled components are structurally integrated resulting in a watertight vessel. The completed vessel shall be capable of withstanding the full hydrostatic head from the exterior of the station while the station is completely empty.
- B. The cylinder shall be made of FRP using the filament winding process. A safety factor of two (2) on the minimum ultimate tensile strength of the laminate bottom shall be used in designing the basin and cylinder wall thicknesses for the station, taking into account all normally imposed loads arising from floatation, soil pressures, normal backfill, handling loads, operating loads and static loads imposed by equipment used in hoisting the pumps in and out of the station.
- C. The cylinder is a filament wound laminate constructed by saturating continuous strand glass roving in a controlled pattern over a corrosion liner that is to be 110 mils minimum thickness. The roving's shall be applied uniformly throughout the entire length of the cylinder as required to provide adequate thickness for the mechanical loads of each application. The winding pattern shall be a combination of helical and hoop wraps and shall produce a dense laminate without non-reinforced resin pockets or air bridging between the rovings. The glass content of the structural laminate shall be 60% to 70% by weight.

- D. The station bottom is a 30% to 50% glass content, chop spray laminate, constructed by built-up alternating layers of chop spray and woven roving applied along with a catalyzed isophthalic resin. Each layer shall be properly wetted out and rolled out so that it is free of air voids until the required wall thickness has been obtained.
- E. All inside surfaces shall be smooth and free of cracks and crazing. All surfaces other than those made in contact with the mold surface shall be coated with air-inhibited resin or gel coat; this includes any cut edges of laminate.
- F. The station shall be provided with one (1) anti-flotation flange located near the bottom of the station. This anti-flotation flange is an integral part of the station and is sufficient in design to withstand the forces acting upon the station due to the subsoil water pressure. Once the station is inserted into the hole, concrete ballast may be required depending on the station depth, please refer to the recommendations for concrete ballast as recommended in Flygt's TOP Station Operations and Maintenance manual. The combination of the flange and the loading of backfill material over the concrete shall provide adequate ballast against buoyancy under full hydrostatic head conditions.

1.5 TOP STATION COVER:

- A. The TOP station cover shall be of 1/4-inch thick Type-5086 aluminum diamond plate with an integral Safe-Hatch access cover. All bars, angles and shapes shall be type 6061-T6 aluminum. The access cover frame shall be a minimum of 4-inches deep and shall be adequately sized to allow for easy passage of the submersible pumps. The Safe-Hatch access cover shall be designed to support the weight of the pump unit plus pedestrian traffic. The access door(s) shall be equipped with a hold-open arm, held open in the 90-degree position. Cover door hinges shall be heavy-duty design and be cast 1/4-inch thick Type 316 stainless steel with 3/8-inch diameter stainless steel hinge pins. All fasteners shall be type-316 stainless steel. Each hatch shall be supplied with a type-316 stainless steel slam lock, having a key-way protected by a threaded plug. The plug shall be flush with the diamond plate cover. The hatch shall be equipped with an aluminum lift handle that shall be flush to the top of the diamond plate cover.
- B. The station lid shall have an integral four-inch diameter stub-pipe connection for the purpose of venting the pump station. The inverted J-shaped vent pipe shall be schedule 40 PVC pipe and shall end at a point at least 3-foot above the elevation of the station cover. There shall also be an option for a second vent to accommodate positive ventilation of the wet well.
- C. The access cover unit shall be equipped with a Safe-Hatch hinged safety grate to provide protection against fall-through and to control access into the confined space. Grate openings shall be sized to allow for routine maintenance inspection without having to open the safety grate. The closed safety grate shall be designed to support the weight of one pump to facilitate

site pump wash-down and inspection. The hatch opening will have a 4" elevated toe board to prevent tools from being kicked into the wet well (per OSHA 1926.502 (j)).

1.6 PIPING AND VALVES:

- A. The Flygt TOP pre-engineered fiberglass pump station shall be furnished complete with discharge pipes, fittings, check valves and shut-off valves. Discharge piping shall be of (PVC / Stainless Steel). The check valves shall be (Flygt-HDL Type-5087 ball-type, cast iron ANSI Class 125 flanged / ValMatic flap-type). The shut-off valves shall be ¼-turn eccentric plug-type, cast iron ANSI Class 125 flanged, with 100% port area (6" model has an 88% port opening) and shall be suitable for the intended purpose.

1.7 TESTING:

- A. STANDARD PUMP FACTORY TEST: Each completed and assembled pump/motor unit shall undergo the following factory tests at the manufacturer's plant prior to shipment:
- Minimum 3-Point Hydraulic Performance Test
 - No-Leak Seal Integrity Test
 - Electrical Integrity Test
- B. FIELD START-UP: After installation, a pump station start-up shall be performed by the installing contractor under the supervision of the manufacture's authorized representative. Field service shall be provided by an authorized, factory trained representative of the pump manufacturer. Services shall include, but not be limited to, inspection of the completed pump station installation to ensure that it has been performed in accordance with the manufacturer's instructions and recommendations, supervision of all field-testing and activation of the Pump Manufacturer's Warranty. The test shall demonstrate to the satisfaction of the Owner that the equipment meets all specified performance criteria, is properly installed and anchored, and operates smoothly without exceeding the full load amperage rating of the motor. The Contractor shall be responsible for coordinating the required field services with the Pump Manufacturer.

1.8 WARRANTY:

- A. STATION WARRANTY: The Pump Manufacturer shall Warrant to the Owner the TOPs pre-engineered fiberglass pump station components against defects in material and workmanship for a period of 1 year from date of start-up or 18 months from date of shipment, whichever is sooner. This warranty shall cover the cost of labor and materials, excluding removal and reinstallation costs, required to correct any warrantable defect, FOB, Manufacturer's authorized warranty service location.
- B. PUMP WARRANTY: Manufacturer's standard warranty covers the pumps.

END OF SECTION 221429

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SECTION 224000**PLUMBING FIXTURES****PART 1 – GENERAL****1.1 SUMMARY**

- A. This Section includes plumbing fixtures and trim, fittings, and accessories, appliances, appurtenances, equipment, and supports associated with plumbing fixtures.
- B. Products installed but not furnished under this Section include:
 - 1. Accessories, appliances, appurtenances, and equipment specified in other sections, requiring plumbing services or fixture-related devices, as indicated.

1.2 DEFINITIONS

- A. Accessible: Describes a plumbing fixture, building, facility, or portion thereof that can be approached, entered, and used by physically handicapped people.
- B. Accessory: Device that adds effectiveness, convenience, or improved appearance to a fixture but is not essential to its operation.
- C. Appliance: Device or machine designed and intended to perform a specific function.
- D. Appurtenance: Device or assembly designed to perform some useful function when attached to or used with a fixture.
- E. Equipment: Device used with plumbing fixtures or plumbing systems to perform a certain function for plumbing fixtures but that is not part of the fixture.
- F. Fitting: Fitting installed on or attached to a fixture to control the flow of water into or out of the fixture.
- G. Fixture: Installed receptor connected to the water distribution system, that receives and makes available potable water and discharges the used liquid or liquid-borne wastes directly or indirectly into the drainage system. The term "Fixture" means the actual receptor, except when used in a general application where terms "Fixture" and "Plumbing Fixture" include associated trim, fittings, accessories, appliances, appurtenances, support, and equipment.
- H. Roughing-In: Installation of piping and support for the fixture prior to the actual installation of the fixture.

- I. Support: Device normally concealed in building construction, for supporting and securing plumbing fixtures to walls and structural members. Supports for urinals, lavatories, and sinks are made in types suitable for fixture construction and the mounting required. Categories of supports are:
 - 1. Reinforcement: Wood blocking or steel plate built into wall construction, for securing fixture to wall.
- J. Trim: Hardware and miscellaneous parts, specific to a fixture and normally supplied with it required to complete fixture assembly and installation.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product data for each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.
- C. Wiring diagrams for field-installed wiring of electrically operated units.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with requirements of the North Carolina State Building Code and the Americans with Disabilities Act.
- B. Listing and Labeling: Provide electrically operated fixtures specified in this Section that are listed and labeled.
 - 1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- C. Design Concept: The drawings indicate types of plumbing fixtures and are based on the specific descriptions, manufacturers, models, and numbers indicated. Plumbing fixtures having equal performance characteristics by other manufacturers may be considered provided that deviations in dimensions, operation, color or finish, or other characteristics are minor and do not change the design concept or intended performance as judged by the Architect. Burden of proof for equality of plumbing fixtures is on the proposer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver plumbing fixtures in manufacturer's protective packing, crating, and covering.

- B. Store plumbing fixtures on elevated platforms in a dry location.

1.6 EXTRA MATERIALS

- A. Deliver extra materials to Government. Furnish extra materials described below matching products installed, packaged with protective covering for storage, and identified with labels clearly describing contents.
 - 1. Faucet Washers and O-rings: Furnish quantity of identical units not less than 10 percent of amount of each installed.
 - 2. Flushometer Repair Kits: Furnish quantity of identical units not less than 10 percent of amount of each flushometer installed.
 - 3. Provide a hinged-top wood or metal box, or individual metal boxes, having a separate compartment for each type and size of above extra materials.
 - 4. Toilet Seats: Furnish quantity of identical units not less than 10 percent of amount of each type toilet seat installed.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products in each category, by one of the following listed for that category:
 - 1. Water Closets:
 - a. American Standard, Inc.
 - b. Eljer; A Household International Co.
 - c. Kohler Co
 - d. Crane
 - e. Zurn Industries, Inc.
 - 2. Lavatories:
 - a. American Standard, Inc.
 - b. Eljer; A Household International Co.
 - c. Kohler Co.
 - d. Crane
 - e. Zurn Industries, Inc.
 - 3. Urinals:
 - a. American Standard, Inc.
 - b. Eljer; A Household International Co.
 - c. Kohler Co.
 - d. Crane
 - e. Zurn Industries, Inc.

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4. Sinks:
 - a. Elkay Manufacturing Co.
 - b. Just Manufacturing Co.
 - c. Moen Group; Stanadyne Corp.
 - d. Kohler
5. Mop Basins:
 - a. Crane Plumbing/Fiat Products.
 - b. Florestone Products Co., Inc.
 - c. Stern-Williams Co., Inc.
 - d. Zurn Industries, Inc.
6. Electric Water Coolers:
 - a. EBCO Manufacturing Co.
 - b. Elkay Manufacturing Co.
 - c. Halsey Taylor; A Household International Co.
 - d. Haws Drinking Faucet Co.
2. Toilet Seats:
 - a. Bemis Mfg. Co.
 - b. Beneke Div.; Sanderson Plumbing Products, Inc.
 - c. Church Seat Co.
 - d. Kohler Co.
 - e. Olsonite Corp.
 - f. Sperzel Industries, Inc.
8. Commercial/Residential Cast-Brass and Cast-Brass Underbody Faucets:
 - a. Chicago Faucet Co.
 - b. Crane Plumbing/Fiat Products
 - c. Delta Faucet Co.; Div. of Masco Corp.
 - d. Moen Group; Stanadyne Corp.
 - e. Price Pfister, Inc.
 - f. Speakman Co.
 - g. gSymmons Industries, Inc.
 - h. T & S Brass and Bronze Works, Inc.
 - i. Zurn Industries, Inc.
9. Miscellaneous Fittings (Except Faucets):
 - a. Chicago Faucet Co.
 - b. Crane Plumbing/Fiat Products.
 - c. Eljer; A Household International Co.
 - d. Engineered Brass Company
 - e. Kohler Co.
 - f. McGuire Manufacturing Co., Inc.
 - g. Price Pfister, Inc.
 - h. T & S Brass and Bronze Works, Inc.

- i. Zurn Industries, Inc.
- j. Plumberex Specialty Products, Inc.

- 10. Instantaneous Electric Water Heaters
 - a. Bradford-White Corp.
 - b. Smith: A.O. Smith Water Products Co.
 - c. State Industries, Inc.
 - d. Lochinvar Corp.
 - d. EeMax
 - e. Rheem/Ruud
 - f. Controlled Energy Corporation

2.2 PLUMBING FIXTURES, GENERAL

- A. Provide plumbing fixtures and trim, fittings, other components, and supports as shown on the drawings.

2.3 FAUCETS

- A. Faucets General: Unless otherwise specified, provide faucets that are cast brass with polished chrome-plated finish.
- B. Lavatory Faucets: ASME A112.18.1M, centerset fitting, with hot and cold handles, and 1/2-gpm flow control fitting in spout.
- C. Sink Faucet: ASME A112.18.1M, centerset fitting, with hot and cold handles and swing spout.
- D. Mop Basin Faucet: ASME A112.18.1M, rough chrome finish, cast brass, with stops in shanks; wall brace, integral vacuum breaker, pail hook, and garden hose thread on spout; and hose and bracket.
- E. Shower Faucet: ASME A112.18.1M, single handle, thermostatic pressure balancing mixing valve, single bronze stem housing stainless steel balancing piston sealed into stem assembly, chrome plated trim, integral service stops, and 2.5 gpm flow.

2.4 FITTINGS, EXCEPT FAUCETS

- A. Fittings General: Unless otherwise specified, provide fittings fabricated of brass, with a polished chrome plated finish.

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- B. Lavatory Supplies and Stops: Angle stops, having 1/2-inch NPS inlet with wall flange and 3/8-inch flexible tubing riser outlet.
- C. Lavatory Traps: Cast-brass, 1-1/4-inch by 1-1/2-inch NPS adjustable P-trap with cleanout, 17-gage tubular waste to wall, and wall flange. Nuts, traps, and wall flanges shall be all brass.
- D. Sink Supplies and Stops: Angle stops, having 1/2-inch NPS inlet with wall flange and 3/8-inch flexible tubing riser outlet.
- E. Sink Traps: Cast-brass, 1-1/2-inch NPS adjustable P-trap with cleanout, 17-gage tubular waste to wall, and wall flange. Nuts, traps, and wall flanges shall be all brass.
- F. Sink Continuous Wastes, Type 2: Polished chrome-plated, tubular brass, 1-1/2 inches, 20 gage, with brass nuts on slip inlets, and of configurations indicated.
- G. Supply and drain plumbing service fittings not listed above shall be as specified and as scheduled.
- H. Fittings installed concealed inside a plumbing fixture or within wall construction may be without chrome plate finish.
- I. Escutcheons: Brass wall flange with set screw.
- J. Deep Pattern Escutcheons: Brass wall flange with set screw of depth adequate to conceal protruding roughing-in fittings.

2.5 PLUMBING FIXTURE SUPPORTS

- A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.
- B. Support categories are:
 - 1. Reinforcement: 2-inch by 4-inch wood blocking between studs or 1/4-inch by 6-inch steel plates attached to studs, in wall construction, to secure floor-mounted and special fixtures to wall.
- C. Support Types: Provide support of category specified, of type having features required to match fixture.
- D. Provide supports specified as part of fixture description, in lieu of category and type requirements above.

2.5 TOILET SEATS

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- A. General: Provide toilet seats compatible with water closets, and of type, color, and features indicated.
- B. Toilet Seats: Heavy-duty, elongated, open front with cover, solid plastic, with self-sustaining check hinge.

2.7 EXPANSION TANKS

- A. General Description: Steel design and constructed, permanently sealed-in air cushion, pre-charged, heavy duty butyl diaphragm mechanical bonded with polypropylene liner to steel shell.

PART 3 – EXECUTION**3.1 EXAMINATION**

- A. Examine roughing-in for potable cold water and hot water supplies and soil, waste, and vent piping systems to verify actual locations of piping connections prior to installing fixtures.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.
- B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:
 - 1. Reinforcement for the following fixtures:
 - a. Wall-mounted lavatories: Wall mounted carriers.
 - b. Wall-mounted sinks required to be secured to wall.
 - c. Recessed, box-mounted electric water coolers.

3.3 INSTALLATION OF PLUMBING FIXTURES

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- A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.
- B. Install wall-mounted, wall-outlet water closets with closet flanges and gasket seals.
- C. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.
- D. Fasten floor-mounted fixtures and special fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.
- E. Fasten wall-mounted fittings to reinforcement built into walls.
- F. Fasten counter-mounting-type plumbing fixtures to casework.
- G. Secure supplies behind wall or within wall pipe space, providing rigid installation.
- H. Set mop basins in leveling bed of cement grout.
- I. Install stop valve in an accessible location above lay-in ceilings in each water supply to each fixture.
- J. Install trap on fixture outlet except for fixtures having integral trap.
- K. Install brass escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern brass escutcheons where required to conceal protruding pipe fittings.
- L. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Division 7 Section "Joint Sealants." Match sealant color to fixture color.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other sections. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
 - 1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections.
 - 2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.5 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.6 ADJUSTING AND CLEANING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at drinking fountains, electric water coolers, faucets, and flushometers having controls, to provide proper flow and stream.
- C. Replace washers of leaking and dripping faucets and stops.
- D. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.

3.7 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities, except when approved in writing by the Government.

3.8 FIXTURE SCHEDULE

- A. Provide plumbing fixtures as scheduled on the drawings.

3.9 WARRANTY

- A. Provide a one-year warranty for all parts and labor and also provide an 11th month inspection of all fixtures and equipment.

END OF SECTION 224000

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SECTION 230100**HVAC GENERAL WORK REQUIREMENTS****PART 1 - GENERAL****1.1. SUMMARY**

- A. This section includes general requirements and information for Division 23 and 25 work.

1.2. DEFINITIONS

- A. Definitions:
1. Occupancy Conditions:
 - a. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion.
 2. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
 3. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
 4. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
 5. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
 6. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3. INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4. QUALITY ASSURANCE

A. Welding Qualifications:

1. Installer Qualifications: Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
 - a. AWS D1.1, "Structural Welding Code--Steel."
 - b. AWS D1.2, "Structural Welding Code--Aluminum."
 - c. AWS D1.3, "Structural Welding Code--Sheet Steel."
 - d. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - e. ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

- B. Roof warranties: All work on roofs shall comply with the roof manufacturer's warranty requirements. For work on existing roofs, obtain a copy of the owner's roof warranty prior to the start of work.

1.5. WARRANTY

- A. Project Warranty: All work performed and all materials installed in Division 23 shall be warrantied by the Contractor for 1 year from the Owner's written acceptance of substantial completion. The warranty shall include all labor and parts. The Contractor shall be on site within 48 hours of Owner notifications.
1. This warranty does not waive the Owner's obligation to provide routine maintenance. Routine maintenance includes maintenance recommended by each equipment manufacturer and industry standard requirements for overall systems as documented in the project's Operation and Maintenance Manuals. Replacement of wear items such as filters, belts, etc. are not included in the warranty unless they are incidental to other warranty work being performed. Failures due to the lack of routine maintenance are the responsibility of the Owner.
 2. Equipment manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the obligations of the Project Warranty.
 3. Extended or special warranties defined in other sections shall be in addition to, and run concurrently with, the Project Warranty.

1.6. PROJECT DOCUMENTS

- A. The Division 23 project documents are diagrammatic in nature and are intended to represent complete and functioning systems. If any aspect of the work is undefined or unclear, submit your questions in writing prior to the final addendum deadline as defined in the specifications and/or at the pre-bid conference. If any aspect of the work is undefined or unclear after the final addendum, include the cost for the

highest quality solution. The contractor is encouraged to thoroughly review the contract documents and site conditions prior to bidding.

- B. Listed Manufacturers: Manufacturers listed in the Division 23 specification sections and on drawings must meet all the requirements of the project documents. Listed manufacturers that do not meet the requirements will not be accepted. The manufacturer listing does not result in an automatic approval. In addition to construction and performance requirements, the proposed equipment must meet the indicated physical dimension, weight, acoustic, power, controls, and plumbing limitations of the project. Verify existing conditions in the field, when applicable, and proposed conditions prior to submitting equipment for Engineer review. When full project coordination drawings are not required, generate coordination drawings to the level of detail necessary to determine if the proposed equipment will comply with the project documents and manufacturer recommended maintenance clearances.
1. If a manufacturer's equipment does not meet the physical dimension, weight, acoustic, power, controls and plumbing limitations of the project, a change order proposal may be submitted for the Owner's and Engineer's consideration. The proposal shall include all changes, including other trades, required and a reduction in cost to accept the non-conforming equipment. The base bid shall include equipment that fully meets the design requirements at no additional cost.

1.7. COORDINATION

- A. Maintenance Access: Install equipment and devices in such a manner to be readily accessible for testing, adjusting, balancing, inspection and maintenance. All concealed equipment and devices, including but not limited to equipment, valves, dampers, actuators, sensors, gauges, test ports, filter housings, coils, etc., shall be installed above accessible ceilings, within accessible rooms or chases or within normally inaccessible construction with access doors. All access doors are not shown in the project drawings. All access doors shall be coordinated with the Engineer prior to the installation of the equipment or device. Equipment and/or devices not coordinated prior to installation, as judged by the Engineer, shall be removed and reinstalled at no added cost.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

1.8. VOC CONTENTS

- A. Low Volatile Organic Compounds (VOC) Requirements: All adhesives, mastics, sealants and compounds factory or field applied that are installed indoors and all

paint field applied shall be certified as low VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Adhesives: 50 g/L or less, except 80 g/L or less for calcium silicate and mineral fiber insulation and 30 g/L or less for metal-to-metal adhesives.
2. Mastics: 50 g/L or less.
3. Sealants: 250 g/L or less for duct sealants and 420 g/L or less for equipment insulation joint sealants.
4. Compounds: 490 g/L or less for CPVC welding compounds and 510 g/L or less for PVC welding compounds.
5. Paints: 50 g/L or less for flat paints and primers and 150 g/L or less for non-flat paints.

PART 2 - PRODUCTS

2.1. PAINTS AND PRIMERS

- A. General: Provide primers and paints designed for the intended applications. All primers and paints used indoors shall be low-odor and low VOC content type.
- B. Primers:
 1. Metal Applications: Water-based rust-inhibitive primer.
 2. Aluminum Applications: Quick-drying primer for aluminum.
 3. Wood Applications: Latex-based wood primer.
 4. Interior Applications: Interior latex primer/sealer.
- C. Paints:
 1. Interior Applications: High-performance interior latex.
 2. Exterior Applications: Exterior latex.
 3. Match gloss level to adjacent finishes when applicable. Flat gloss level for all other applications, unless otherwise indicated.

2.2. PATCHING MATERIALS

- A. General: Comply with requirements specified in other Sections.

- B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
 - 1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

2.3. ESCUTCHEONS AND FLOOR PLATES

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

PART 3 - EXECUTION

3.1. OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

- A. Permanent HVAC systems and components may only be operated for verification, testing, adjusting and balancing.
- B. Owner/Engineer shall approve project conditions prior to system start-ups. Request start-up inspection minimum of 2 weeks prior to proposed start. Proposed start shall be coordinated with Owner's/Engineer's schedule.
- C. Air System Temporary Operation: Systems shall only be operated when the building is completely enclosed, is clean and there are no dust or fume creating activities being performed.
 - 1. Filtration: Prior to starting air systems, verify clean filters are installed in all air system equipment and clean temporary filter media is installed on all air intakes. Replace temporary filters on a regular basis. Provide minimum MERV-8 temporary filter media and comply with Section 234100. Replace all filters with new prior to Owner acceptance.
- D. Owner/Engineer must approve operation of the permanent HVAC systems for use at substantial completion.

3.2. PAINTING

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
- B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and re-prime substrate with compatible primers as required to produce paint systems indicated.
- C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- D. Painting of Division 23 Work: Paint items exposed in equipment rooms and occupied spaces including, but not limited to, the following:
 - 1. Visible portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets.
 - 2. Duct, equipment, and pipe insulation having cotton, canvas or metal insulation covering or other paintable jacket material as required by Section 230553 and elsewhere as indicated.
 - 3. Mechanical equipment that is indicated to have a factory-primed finish for field painting.
- E. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.
- F. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.3. PIPING SYSTEM INSTALLATION GENERAL REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs. Refer to Section 230517 for more information about sleeves and sleeve seals.
- M. Verify final equipment locations for roughing-in.
- N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- O. Piping Connections: Make piping connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping 2-inches NPS and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 3. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4. ESCUTCHEONS AND FLOOR PLATES INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with inside diameter to closely fit around pipe, tube, and insulation of piping and with outside diameter that completely covers opening.
- C. New Piping: Install one-piece cast-brass type for new piping installations. Install deep-pattern type where piping sleeve protrudes from the floor or wall.

3.5. EQUIPMENT INSTALLATION GENERAL REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

END OF SECTION 230100

SECTION 230110**HVAC SUBMITTAL LIST****PART 1 - GENERAL****1.1. SUMMARY**

- A. This section is a supplement to the Division 23 specification sections. Submittal descriptions in this section are not intended to alter the requirements defined in other sections.

1.2. HVAC SUBMITTAL LIST

SUBMITTAL SCHEDULE

PRE-CONSTRUCTION	
SECTION	DESCRIPTION
23 04 00	COORDINATION DRAWINGS
23 05 11	ELECTRICAL DEVICES - ENCLOSURES, DISCONNECTS & STARTERS
23 05 14	VARIABLE SPEED CONTROLLERS
23 05 14	HARMONIC DISTORTION ANALYSIS
23 05 48	DELEGATED DESIGN FOR SEISMIC, VIBRATION AND WIND CONTROL
23 05 48	VIBRATION CONTROL DEVICES
23 05 48	SEISMIC AND VIBRATION CONTROL DEVICES
23 05 53	IDENTIFICATION DEVICES
23 05 93	T/A/B QUALIFICATIONS
23 05 93	T/A/B CONTRACT DOCUMENT EXAMINATION REPORT
23 05 93	T/A/B PROCEDURE PLAN
23 05 93	T/A/B INSTRUMENT CALIBRATION REPORTS
23 07 13	DUCT INSULATION

23 07 16	EQUIPMENT INSULATION
23 31 13	DUCT SHOP DRAWINGS
23 31 13	DUCT SCHEDULE AND MATERIALS
23 33 00	DUCT ACCESSORIES
23 34 23	FANS
23 36 00	AIR TERMINAL UNITS
23 37 13	DIFFUSERS, GRILLES AND REGISTERS
23 41 00	PARTICULATE AIR FILTRATION - STANDARD EFFICIENCY
23 62 13	PACKAGED ROOFTOP UNITS
23 74 33	DEDICATED OUTDOOR AIR UNITS
23 81 16	DUCTLESS MINI-SPLIT SYSTEMS
25 01 00	DDC CONTROLS WITH PROTOCOL CERTIFICATES
25 01 00	SENSORS AND DETECTION DEVICES
25 01 00	ACTUATORS
25 01 00	CONTROL DAMPERS
DURING CONSTRUCTION	
SECTION	DESCRIPTION
23 02 00	INSTRUCTION PROGRAM
23 05 93	T/A/B REPORTS
23 05 93	T/A/B INSTRUMENT CALIBRATION REPORTS
23 31 13	DUCT LEAKAGE TEST REPORTS
23 33 00	LIFE-SAFETY DAMPER TESTING REPORTS
	EQUIPMENT START-UP REPORTS
CONSTRUCTION CLOSE OUT	
SECTION	DESCRIPTION

23 01 00	PROJECT WARRANTY
23 05 93	T/A/B FINAL REPORT
	OPERATION AND MAINTENANCE MANUALS
	AS-BUILT RECORD DRAWINGS
	EXTRA MATERIALS PROOFS OF RECEIPT

END OF SECTION 230110

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SECTION 230200**HVAC SYSTEMS OWNER TRAINING****PART 1 - GENERAL****1.1. SUMMARY**

- A. This section includes general requirements for the owner's demonstration and training of Division 23 systems and equipment.

1.2. INFORMATIONAL SUBMITTALS

- A. Instruction Program: Submit outline of instructional program for demonstration and training including proposed dates, times, lengths of instruction times, instructor's name and instructor's qualifications.

1.3. QUALITY INSURANCE

- A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.
- B. Instructor Qualifications: A factory-authorized service representative experienced in operation and maintenance procedures and training.
- C. Pre-Instruction Conference: Conduct conference at the project site. Review methods and procedures related to demonstration and training.
- D. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS**2.1. INSTRUCTION PROGRAM**

- A. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:
 - 1. HVAC Control Systems
 - 2. Flow and Energy Meters

3. Motor Starters and Disconnect Switches
 4. Variable Speed Drives
 5. Life-Safety Dampers
 6. Fans, Supply, Return, Relief and Exhaust
 7. Terminal Units
 8. Air Handling Units, Packaged and Modular
 9. Packaged Rooftop Units
 10. Unit Heaters
 11. Ductless Mini-Split System Units
- B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:
1. Basis of System Design, Operational Requirements and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
 2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
 3. Emergencies: Include instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.
 4. Operations: Include startup, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.
 5. Adjustments: Include alignments and checking, noise, vibration, economy, and efficiency adjustments.
 6. Troubleshooting: Include diagnostic instructions and test and inspection procedures.
 7. Maintenance: Include inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.

8. Repairs: Include diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1. INSTRUCTION

- A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.
- B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.
- C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.
 1. Schedule training with Owner with at least 30 days' advance notice.

END OF SECTION 230200

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SECTION 23 04 00**HVAC COORDINATION DRAWINGS****PART 1 - GENERAL****1.1. SUMMARY**

- A. This section includes general requirements for coordination drawings.

1.2. COORDINATION DRAWING SUBMITTALS

- A. Responsibilities: The Mechanical Contractor shall compile and complete the coordinated information provided in cooperation from the sub-contractors and vendors.
- B. Coordination Drawings: Floor plans, including reflected ceiling, enlarged and partial site plans, sections and other details drawn to scale on which the following items are shown and coordinated with each other, using input from installers of the items involved.
 - 1. Floor plan drawings shall be produced at 1/8, 1/4 and 1/2-inch equals 1 foot scale as needed to clearly represent the information. Mechanical and electrical rooms shall be produced at no less than 1/4-inch scale.
 - 2. Site plan drawings shall be produced at 1-inch equals 10 or 20 feet as needed to clearly represent the information.
 - 3. Dimensions, weights and mounting elevations shall be provided.
- C. Coordinated Floor Plan Drawings: Floor plans with sufficient information to coordinate the building systems to avoid conflicts, including the following:
 - 1. HVAC Systems:
 - a. Duct Systems, including Insulation Thicknesses
 - b. Louvers and Ventilators
 - c. Piping Systems, including Insulation Thicknesses
 - d. Equipment including Maintenance Clearances
 - e. HVAC Control Systems
 - 2. Fire Protection Systems:
 - a. Piping Systems

- b. Zone Control Valve Assemblies
 - c. Backflow Prevention
 - d. Equipment including Maintenance Clearances
 - 3. Plumbing Systems:
 - a. Piping Systems, including Insulation Thicknesses
 - b. Backflow Prevention
 - c. Equipment including Maintenance Clearances
 - d. Energy and Flow Meters
 - e. Vents Through Roof
 - 4. Electrical
 - a. Switchgear and Panelboards
 - b. Equipment including Maintenance Clearances
 - c. Conduit, 3-inches and larger or equivalent groups of smaller
 - 5. Structural Members
 - 6. Variable Speed Drives, Motor Starters and Disconnects
 - 7. Vibration and Seismic Controls
 - 8. Equipment Supports, Roof Curbs and Concrete Pads
 - 9. Ceiling Heights
- D. Coordinated Reflected Ceiling Plans: Ceiling layout with all components located and coordinates, including ceiling materials, ceiling access doors, light fixtures, sprinkler heads, diffusers and grilles, fire alarm devices, lighting control devices, HVAC control sensors, communications and audio-visual devices.
 - 1. Access to equipment and devices above ceiling shall be coordinated such that they are accessible from a ladder without moving other ceiling mounted devices. Proposed access door locations must be approved by the Owner/Engineer.
- E. Coordinated Site Plans: Partial site plans with site work including service piping, conduits, manholes and equipment.

1.3. CLOSEOUT SUBMITTALS

- A. Record Drawings: Revise Coordination Drawings to include the changes made in the field to accurately reflect the as-built conditions.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 23 04 00

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SECTION 230511**HVAC ELECTRICAL PROVISIONS****PART 1 - GENERAL****1.1. SUMMARY**

- A. This section includes electrical equipment, materials and work that are the responsibility of Division 23.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of device, include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.
- B. Electrical Connections: Submitted equipment nameplates shall be coordinated with the indicated design electrical characteristics. If the submitted equipment requires changes to the electrical connection(s) (including conduit, wire, circuit breaker, fuse, starter, and disconnect sizes, connection locations, etc.) comply with the requirements of Section 230100. Any changes required to accommodate the equipment shall be responsibility of the contractor.
 - 1. Proposed changes to the design shall be submitted to the Engineer for review and approval.
 - 2. Accepted changes shall be noted by the contractor on the as-built documentation.

1.3. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For disconnects, motor starters and combination motor starters and disconnects, to include in emergency, operation and maintenance manuals.

1.4. QUALITY ASSURANCE

- A. Source Limitations: Obtain motor starters, disconnect switches and combination motor starters and disconnect switches of a single type through one source from a single manufacturer.
 - 1. Exceptions: Disconnect switches that are factory-mounted to HVAC equipment may be provided by the equipment manufacturer.

- B. Electrical Components, Devices, and Accessories: UL listed and labeled and complying with NFPA 70 and Division 26.
 - 1. Where requirements of Division 23, Division 26 or NFPA 70 conflict, conform to the strictest requirements.

1.5. MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One set for each fused device.

PART 2 - PRODUCTS

2.1. EQUIPMENT ENCLOSURES

- A. Provide NEMA-rated equipment enclosures for all disconnect switches, motor starters, control panels, variable speed controllers and other similar electrical equipment. When not otherwise indicated, provide enclosures based on the environments of the installations.
 - 1. Inside, Clean Spaces without Water Piping: NEMA 1.
 - 2. Inside, Utility Spaces and Spaces with Water Piping: NEMA 12.
 - 3. Outside, Normal Ambient Conditions: NEMA 3R.

2.2. DISCONNECT SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Eaton
 - 2. Emerson
 - 3. Hubbell
 - 4. General Electric
 - 5. Rockwell Automation/Allen Bradley
 - 6. Schneider Electric/Square D
 - 7. Siemens

- B. Fusible Disconnect Switches: Single-throw, heavy-duty, service-rated fusible switch, rated for 200 to 600Vac and labeled and listed UL 98 and NEMA KS 1, Type HD with silver-tungsten type fuse clips and equipment ground and neutral kit. When a neutral is not necessary, bond the neutral bus to the enclosure for use as grounding bus. Internal current-carrying components shall be solid copper. Provide auxiliary contacts when needed for control system interface.
- C. Non-Fusible Disconnect Switches: Single-throw, heavy-duty, service-rated switch, rated for 200 to 600Vac and labeled and listed UL 98 and NEMA KS 1, Type HD with equipment ground and neutral kit. When a neutral is not necessary, bond the neutral bus to the enclosure for use as grounding bus. Internal current-carrying components shall be solid copper. Provide auxiliary contacts when needed for control system interface.
- D. Provide switch accessories required to meet the system requirements indicated.

2.3. MOTOR STARTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Eaton
 - 2. Emerson
 - 3. Hubbell
 - 4. General Electric
 - 5. Rockwell Automation/Allen Bradley
 - 6. Schneider Electric/Square D
 - 7. Siemens
- B. Description: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system requirements indicated. Cover door shall have red and green pilot lights. The green light shall illuminate when "on", and red shall illuminated when "off".

2.4. COMBINATION MOTOR STARTERS AND DISCONNECT SWITCHES

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

2. Emerson
 3. Hubbell
 4. General Electric
 5. Rockwell Automation/Allen Bradley
 6. Schneider Electric/Square D
 7. Siemens
- B. Description: Combination magnetic motor starter and circuit breaker disconnecting means with auxiliary contacts.
1. Motor Starter: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system requirements indicated. Cover door shall have red and green pilot lights. The green light shall be illuminated when "on", and red shall be illuminated when "off".
 2. Disconnecting Means: Thermal magnetic type molded-case circuit breaker (MCCB) with adjustable instantaneous-trip for each pole, auxiliary control and monitoring contacts and test trip button.

2.5. MANUAL MOTOR SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Eaton
 2. Emerson
 3. Hubbell
 4. General Electric
 5. Rockwell Automation/Allen Bradley
 6. Schneider Electric/Square D
 7. Siemens
- B. Description: Manual motor starter and disconnect switch with thermal overload protection for fractional horsepower motors. Toggle switch shall provide manual "on/off" control of one or two-pole single-phase motors rated up to 1 horsepower. The enclosure shall have green pilot light. The green light shall illuminate when "on". The switch shall have a hand guard to prevent accidental operation and provisions for a padlock in the "off" position. The switch shall be rated for single or two-speed

applications as indicated. The enclosure shall be for flush wall-mounting where possible and surface wall-mounting where not.

2.6. FUSES

- A. Description: Non-renewable cartridge fuses of the type and size required by NFPA 70 and Division 26.

2.7. SHORT-CIRCUIT CURRENT RATINGS

- A. Overcurrent protection devices shall be rated for the ampere interruption current rating indicated in the Division 26 documents. Where the rating is not indicated, provide devices rated for 65,000 AIC.

2.8. POWER AND CONTROL CABLING AND RACEWAY

- A. Low-Voltage (100 to 600 V) Power Feeders: Size conductors and raceway per NFPA 70 and Division 26 based on equipment nameplate requirements and manufacturer's installation recommendations.
- B. Control-Voltage (Up to 24 V) Cabling: Provide control cabling for HVAC system per NFPA 70 and Division 26 based on the system manufacturer's installation recommendations.
 - 1. Paired Cabling: No. 16 AWG Type CMP plenum-rated twisted pair.
 - 2. Class 1 and 2 Control Circuits: Stranded copper Type THHN-THWN.
 - 3. Class 3 Control Circuits: Stranded copper Type TW or TF.
- C. Power Conductors: Copper, solid for No. 10 AWG and smaller and stranded for No. 8 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.
- D. Grounding Conductors: Copper, solid for No. 8 AWG and smaller and stranded for No. 6 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.
- E. Conduit:
 - 1. EMT (electrical metallic tubing): Indoor, above-grade applications not subject to damage.
 - 2. RGS (rigid galvanized steel): Indoor, above-grade applications subject to damage and outdoor, above-grade applications.
 - 3. RNC (rigid non-metallic conduit), Type Schedule 40 PVC: Indoor and outdoor, below-grade applications.

4. FMC (flexible metallic conduit): Indoor, above-ceiling applications.
5. LFMC (liquid-tight flexible metal conduit): Outdoor, above-grade applications.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Disconnect Switches: Provide disconnect switches for all HVAC equipment. Disconnect switches shall be sized to comply with NFPA 70. Single fan, blower and pump motors shall be based on nameplate horsepower. All other applications shall be based on nameplate total kW rating. Disconnects shall be provided with dual-element fuses sized based on equipment nameplate rating.
1. Service Disconnect Switches: Where the disconnecting means is not within the line-of-sight, as defined by NFPA 70 and the authority having jurisdiction (AHJ), an additional service disconnect shall be located adjacent to the equipment it feeds.

DISCONNECT SWITCH SIZES for MOTORS						
AMPERAGE RATING	MAX HP at VOLTAGE/PHASE					
	115V/1p h	200V/1p h	230V/1p h	200V/3p h	230V/3p h	460V/3p h
30A	1.5	3	3	5	7.5	15
60A	3	7.5	10	15	15	30
100A	-	-	-	25	25	60
200A	-	-	-	50	60	100
400A	-	-	-	100	125	250

DISCONNECT SWITCH SIZES for EQUIPMENT							
AMPERAGE RATING	MAX KW at VOLTAGE/PHASE						
	120V/1 ph	208V/1 ph	240V/1 ph	277V/1 ph	208V/3 ph	240V/3 ph	480V/3 ph
30A	2.8	5.0	5.8	6.6	8.6	10.0	19.9

60A	5.8	10.0	11.5	13.3	17.3	19.9	39.9
100A	9.6	16.6	19.2	22.2	28.8	33.2	66.4
200A	19.2	33.3	38.4	44.3	57.6	66.4	132.9
400A	38.4	66.6	76.8	88.6	115.1	132.9	265.7
600A	57.6	99.8	115.2	133.0	172.7	199.3	398.6

- B. Motor Starters: Provide all motor starters where required for HVAC equipment to operate as intended. Motor starters shall be sized to comply with NFPA 70 and NEMA rated for magnetic starters.

NEMA STARTER SIZES					
NEMA SIZE	MAX HP at MOTOR VOLTAGE/PHASE				
	115V/1ph	230V/1ph	200V/3ph	230V/3ph	460V/3ph
00	0.33	1	1.5	1.5	2
0	1	2	3	3	5
1	2	3	7.5	7.5	10
2	-	7.5	10	15	25
3	-	-	25	30	50
4	-	-	40	50	100
5	-	-	75	100	200

- C. Combination Motor Starters and Disconnect Switches: Provide combination motor starters and disconnect switches that meet the requirements of the "Motor Starters" article above. Combination motor starters and disconnect switches shall be used unless otherwise noted or prohibited by NFPA 70.
- D. Manual Motor Switches: Provide manual motor switches for fractional horsepower fan, blower and pump motors that do not require automated start and stop functions.
- E. Furnish and install device fuses per equipment unit nameplate.

- F. Size and adjust circuit breaker disconnect switches per equipment unit nameplate.
- G. Electrical Connections: All electrical connections shall be made in accordance with equipment manufacturer's recommendations and in accordance with NFPA 70. Install and ground equipment connections in accordance with the requirements of NFPA 70 and Division 26.
 - 1. Electrical Connections, Low Voltage (100 to 600 V): Division 23 contractor is responsible for power wiring and conduit from the equipment connections to the disconnecting means. Division 26 is responsible for the power circuit from the power source to the disconnecting means.
 - 2. Electrical Connections, Control Voltage (Up to 24 V): Division 23 contractor is responsible for all control voltage wiring and conduit for HVAC equipment and controls from the low voltage power source disconnecting means. Division 26 is responsible for the low voltage power circuit from the power source to the disconnecting means.
 - a. Low Voltage Disconnecting Means: Where dedicated low voltage circuits are indicated in Division 26 documents, the disconnecting means shall be defined as the disconnect switch or junction box provided. Where dedicated low voltage circuits are not explicitly indicated in Division 26 documents, the disconnecting means shall be defined as 20A/1P spare circuit breakers in panelboards.
- H. Wiring Pathway, Low and Control Voltage: All low and control voltage power and control wiring shall be installed in conduit unless otherwise noted.
 - 1. Surface-mounted raceway may only be used when indicated or Engineer approved prior to installation. In most cases, conduits shall be installed within walls, above ceilings and below floor slabs. Cut and repair substrates to install raceway.
 - 2. Control voltage cabling shall be plenum-rated and organized with J-hooks when control cabling is not required by the Engineer to be installed in conduit.
- I. Conduit:
 - 1. Flexible Connections: Provide flexible connections for all vibrating equipment including fans, pumps, compressors, etc. Flexible connections shall be no more than 24-inches long.
 - 2. Areas Subject to Damage: In areas where the conduit will be exposed and is subject to damage, such as mechanical equipment rooms, RGS conduit shall be installed to no less than 8-feet above finished floor and EMT may be used above 8-feet.
- J. Grounding and Bonding: Ground and bond equipment and circuits in accordance with the requirements of NFPA 70 and Division 26.

- K. Install duct-mounted smoke detectors, furnished and wired by Division 26. Provide duct access doors for proper maintenance and access.
- L. Smoke-rated life-safety dampers shall be wired and controlled by Division 26.

3.2. FIELD QUALITY CONTROL

- A. Comply with NFPA 70E per OSHA 29CFR Part 1910.5, Appendix A.

3.3. DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain electrical devices.

END OF SECTION 230511

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SECTION 230513**HVAC EQUIPMENT MOTORS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes general requirements for all HVAC motors

PART 2 - PRODUCTS**2.1. GENERAL MOTOR REQUIREMENTS**

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.
- C. Motors for fans and pumps shall be selected for the maximum brake-horsepower listed in the equipment schedules and no more than 85% of the nominal rated horsepower excluding the service factor.

2.2. MOTOR CHARACTERISTICS

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

2.3. POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motors.
 - 1. General Use: Open drip-proof (ODP) motors.
- B. Efficiency: NEMA Premium Efficiency rated motors.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Class B.
- H. Insulation: Class F.
- I. Code Letter Designation:
 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T

2.4. POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 4. Over-Speeding: Variable frequency drives shall not be set above 60 Hz.
 - a. Exceptions:
 - 1) Air Handling Units without Setback Schedules: Variable frequency drives shall not operate over 75 Hz and motors shall not operate over 3,000 RPM for direct-drive fans.
 - 2) Air Handling Units with Setback Schedules: Variable frequency drives shall not operate over 90 Hz and motors shall not operate over 3,000 RPM for direct-drive fans used in air handling units.

2.5. SINGLE-PHASE MOTORS

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

PART 3 - EXECUTION (Not Applicable)**END OF SECTION 230513**

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SECTION 230529**HANGERS AND SUPPORTS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes pipe hangers and hanger shields, fastener systems,

1.2. PERFORMANCE REQUIREMENTS

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

1.3. ACTION SUBMITTALS

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

1.4. INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5. QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1. METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports: MSS SP-58, Types 1 through 58, factory-fabricated components. Hangers shall be galvanized. Padded hangers shall be fiberglass pad or cushion to support bearing surface of piping. Hanger rods shall be continuously threaded with nuts and washers made of carbon steel.
- B. Copper Pipe Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

2.2. TRAPEZE PIPE HANGERS

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

2.3. THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength. For cold piping systems, include vapor barrier.
- B. Insert and shield shall cover the entire pipe circumference for trapeze of clamped systems and cover the lower 180-degrees of pipe circumference for clevis or band hangers.
- C. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4. FASTENER SYSTEMS

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

2.5. MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1. HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- C. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- D. 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.
- E. Install lateral bracing with pipe hangers and supports to prevent swaying.
- F. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 2 1/2-inches NPS 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.
- G. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- H. 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.

3.2. EQUIPMENT SUPPORTS

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

3.3. ADJUSTING

- A. Trim excess length of continuous-thread hanger and support rods to 1 1/2 inches.

3.4. 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 A 780.

3.5. HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports:
 - 1. Adjustable Steel Clevis Hangers (MSS Type 1)
 - 2. Split-Ring Hangers (MSS Type 69): Piping 2-inches NPS and smaller.
 - 3. Copper Pipe Hangers: For copper piping.
- K. Building Attachments: Install MSS compliant devices for all building attachments. Install them per manufacturer's instructions.
- L. Saddles and Shields:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

3.6. PIPE HANGER INSTALLATION

- A. Copper Piping: Install hangers for drawn-temper copper piping with the following minimum rod sizes and maximum spacing:
 1. 1 1/4-inch NPS and smaller: 3/8-inch diameter at 5 foot span.
 2. 1 1/2 to 2-inch NPS: 3/8-inch diameter at 8 foot span.
 3. 2 1/2-inch NPS: 1/2-inch diameter at 9 foot span.
 4. 3-inch NPS: 1/2-inch diameter at 10 foot span.
 5. 4-inch NPS: 5/8-inch diameter at 10 foot span.
- B. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

END OF SECTION 230529

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SECTION 230548**HVAC VIBRATION, WIND AND SEISMIC CONTROLS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes vibration and seismic control devices and related materials, including isolators, mounts, guides and supports.
- B. Description: Delegated design of all equipment and materials installed under Division 23.
 - 1. Vibration Isolation: Applies to all HVAC equipment and materials.
 - 2. Wind Restraints: Applies to all HVAC equipment and materials installed outdoors, above-grade.
 - 3. Seismic Bracing: Applies to all HVAC equipment and materials based on the seismic criteria defined in this section.

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. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation, wind restraint and seismic restraint device required.
- B. Delegated-Design Submittal: For each vibration isolation, wind restraint and seismic restraint device:
 - 1. Include design calculations and details for selecting vibration isolators, wind restraints, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

- a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic and Wind Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.3. QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide product by one of the following for spring and elastomeric isolators:
1. Mason Industries, Inc.
 2. Kinetics Noise Control, Inc.
 3. Vibration Eliminator Company, Inc.
 4. Vibration Mounting & Controls (VMC) Group, Inc.

2.2. PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
1. Basic Wind Speed: 135 MPH
 2. Building Classification Category: III
 3. Minimum 30 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
1. Site Class as Defined in the IBC: D
 2. Seismic Design Category: C
 3. Assigned Building Category as Defined in the IBC: III
 - a. Component Importance Factor: Life Safety Systems, Sprinkler Piping, and Natural Gas Piping 1.5, Other systems 1.0
 - b. Component Response Modification Factor: Per ASCE 7-05, chapter 13
 - c. Component Amplification Factor: Per ASCE 7-05, chapter 13
 4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.218G
 5. Design Spectral Response Acceleration at 1.0-Second Period: 0.091G
 6. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.
- C. Seismic Performance: HVAC equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI-7. 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.

2.3. ELASTOMERIC ISOLATION PADS

A. Description: Elastomeric Isolation Pads.

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Waffle pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: Resilient and elastomeric.
 - a. Surface Pattern: Waffle pattern.
 - b. Infused nonwoven cotton or synthetic fibers.

2.4. ELASTOMERIC ISOLATION MOUNTS

A. Description: Double-Deflection, Elastomeric Isolation Mounts.

1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5. RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Description: Restrained Elastomeric Isolation Mounts.

1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

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

2.6. OPEN-SPRING ISOLATORS

- A. Description: Freestanding, Laterally Stable, Open-Spring Isolators.
 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.7. HOUSED-SPRING ISOLATORS

- A. Description: Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing.
 1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. 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 shall limit floor load to 500 psig.
 - b. Top housing with attachment and leveling bolt or threaded mounting holes and internal leveling device.

2.8. RESTRAINED-SPRING ISOLATORS

- A. Description: Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint.
1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
 - b. Top plate with threaded mounting holes or elastomeric pad.
 - c. Internal leveling bolt that acts as blocking during installation.
 2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 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.

2.9. HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Description: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing.
1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 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.

2.10. PIPE-RISER RESILIENT SUPPORT

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

2.11. RESILIENT PIPE GUIDES

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

2.12. ELASTOMERIC HANGERS

- A. Description: Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods.
 1. 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.
 2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.13. SPRING HANGERS

- A. Description: Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression.
 1. 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.
 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. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.14. SNUBBERS

- A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.15. RESTRAINT CHANNEL BRACINGS

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.16. RESTRAINT CABLES

- A. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.17. SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- C. 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.
- D. 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.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.18. MECHANICAL ANCHOR BOLTS

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.19. ADHESIVE ANCHOR BOLTS

- A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.20. VIBRATION ISOLATION EQUIPMENT BASES

- A. Steel Rails: Factory-fabricated, welded, structural-steel rails.
 - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 - 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
 - 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- B. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
 - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.21. RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
- B. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.
- C. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
- D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

- E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

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.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.
- D. Vibration Isolation: In addition to vibration isolation devices indicated within the project documents, provide isolators per ASHRAE Handbook – “HVAC Applications”, Chapter 48, Table 47 “Selection Guide for Vibration Isolation”.
 - 1. Suspended Piping: Install vibration isolation hangers in all mechanical equipment rooms and on all piping within 50 feet of vibrating equipment connections and steam PRV stations.
 - a. Three hangers closest to each equipment connection shall be rated for deflection equal to the equipment isolator deflection.
 - b. The remaining hangers shall have a deflection of 3/4-inch.
 - c. Exceptions: Not required at terminal equipment connections where the equipment is isolated, such as terminal units, blower coil units, fan coil units and heaters.

2. Noise Sensitive Spaces: All piping 2-inches and larger and ductwork within 50-feet of spaces designated as noise sensitive shall have vibration isolation hangers.

3.3. CONTROL AND RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Equipment Restraints:
 1. Install seismic snubbers on 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 devices.
- D. Piping Restraints:
 1. Comply with requirements in MSS SP-127.
 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 3. Brace a change of direction longer than 12 feet.
- E. Install cables so they do not bend across edges of adjacent equipment or building structure.
- F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Drilled-in Anchors:

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

3.4. ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 for piping flexible connections.

3.5. FIELD QUALITY CONTROL

- A. Perform tests and inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Engineer.

5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

3.6. ADJUSTING

- A. Adjust isolators after piping 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.

3.7. VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

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

END OF SECTION 230548

SECTION 230553**HVAC SYSTEMS IDENTIFICATION****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes equipment, pipe and duct labels and tags.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Valve Schedules: For each piping system to include in maintenance manuals.

1.3. COORDINATION

- 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.

PART 2 - PRODUCTS**2.1. EQUIPMENT LABELS**

- A. Plastic Labels for Equipment: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch white letters on black background.
 - 1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's drawing designation or unique equipment number.

2.2. WARNING SIGNS AND LABELS

- A. Warning Signs and Labels: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch white letters on black background.
 - 1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3. PIPE LABELS

- A. Pipe Labels: Pre-printed, color-coded, self-adhesive vinyl labels with lettering and flow direction arrows. They shall have minimum 1 1/2-inch tall block lettering. The labels shall be suitable for temperatures up to 160 deg F and compatible with each substrate material.

2.4. DUCT LABELS

- A. Duct Labels: Pre-printed, color-coded, self-adhesive vinyl labels with lettering and flow direction arrows. They shall have minimum 1 1/2-inch tall block lettering. The labels shall be suitable for temperatures up to 160 deg F and compatible with each substrate material.

2.5. STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions. Stencil paint shall be exterior, gloss, acrylic enamel.

2.6. CEILING TAGS

- A. Ceiling Tags: 0.030-inch thick and 3/4 to 7/8-inch diameter rigid vinyl, self-adhesive, white or clear plastic tags with pre-printed, minimum 1/8-inch tall block-letter black text indicating the equipment, valve or accessory tag and number designations.

2.7. WARNING TAGS

- A. Warning Tags: 5-1/4 inches wide and 3-inches tall, pre-printed or partially pre-printed, accident-prevention tags, of plasticized card stock with matte finish suitable for writing, fastened with reinforced grommet and wire. Tags shall have Yellow

background and Black letters with large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

2.8. SENSOR TAGS

- A. Sensor Tags: 1/4-inch wide, pre-printed, clear vinyl adhesive tags with 1/8-inch tall block-letter black text. Each sensor shall be clearly and neatly labelled. Tags shall denote the associated piece of equipment, for example "TU-123".

PART 3 - EXECUTION

3.1. PREPARATION

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

3.2. PIPE COLOR AND LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Piping Color Schedule:
 - 1. Refrigerant Piping: Black background with White letters and flow arrows.

3.3. EQUIPMENT COLOR AND LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment. Equipment to be labelled includes but is not limited to:
 - 1. Air handling equipment, including RTU, DOAS, etc.
 - 2. Fans
 - 3. Terminal units
 - 4. Condensing units
 - 5. Split-systems
 - 6. Control panels and main sensors
- B. Central HVAC system equipment labels shall include capacity and design information. Submit proposed label information for Engineer approval. The following are examples:
 - 1. Rooftop Units
 - ROOFTOP UNIT RTU-1
 - INSTALLED: JUNE 2020
 - SERVICE: ADMINISTRATION AREA
 - CAPACITY: 2,000 CFM at 1.0" ESP
 - COOLING: 5 TONS
 - HEATING: 25 KW
 - 2. Fans
 - EXHAUST FAN EF-1
 - INSTALLED: JUNE 2020
 - SERVICE: ROOM 201 FUME HOOD
 - CAPACITY: 500 CFM at 0.5" ESP
- C. Locate equipment labels where accessible and visible.
- D. Equipment Color Schedule: Insulation color and label scheme shall match the associated piping system.

3.4. DUCT COLOR AND LABEL INSTALLATION

- A. Duct Labels: Install self-adhesive duct labels with permanent adhesive on air ducts.

- B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.
- D. Duct Color Schedule:
 - 1. Supply, Return and General Exhaust: White background with Black letters and flow arrows.
 - 2. Refer to Section 230713 for painting requirements.

3.5. CEILING TAG INSTALLATION

- A. Install ceiling tags on lay-in grid and access doors below equipment, valves and accessories above finished ceilings. Center tags on grid members and doors.

3.6. WARNING-TAG INSTALLATION

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

3.7. SENSOR TAG INSTALLATION

- A. Install sensor tags for wall or ceiling-mounted sensors on faceplates centered below the device. Install sensor tags for concealed sensors on sensor enclosures or backboxes. Where sensors are located above lay-in ceilings, behind access doors, or otherwise remotely accessible, label the grid or door in addition to the device itself. Tags shall be centered and neatly applied.

END OF SECTION 230553

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SECTION 230593**TESTING, ADJUSTING AND BALANCING****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes testing, adjusting and balancing (TAB) of air and hydronic systems
 - 1. HVAC Air Systems:
 - a. TAB of new central and dedicated HVAC air systems including supply, return, exhaust, relief and outside air to design requirements.
 - 2. Plumbing Systems:
 - a. TAB of new plumbing systems including domestic hot water recirculation to design requirements.

1.2. INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of the Notice to Proceed, submit documentation that the TAB contractor and the project's TAB team members meet the qualifications specified in "Quality Assurance".
- B. Contract Documents Examination Report: Within 60 days of the Notice to Proceed, submit the contract documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 60 days of the Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation".
- D. Instrument calibration reports, to include the following: instrument type and make; serial number; application; dates of use; and dates of calibration.

1.3. CONSTRUCTION PROGRESS SUBMITTALS

- A. Initial certified TAB reports of individual systems for engineer's review.

1.4. CLOSEOUT SUBMITTALS

- A. Final certified TAB report with all systems in a single report.

1.5. QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by the Associated Air Balance Council (AABC).
 - 1. TAB Field Supervisor: TAB contractor employee who is certified by AABC.
 - 2. TAB Technician: TAB contractor employee who is certified by AABC.
- B. Certify TAB field data reports and perform the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard AABC report forms as reviewed by the engineer.
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE-111, Section 5, "Instrumentation."
 - 1. All instruments shall be calibrated within 6 months of use.
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6. PROJECT 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.

1.7. COORDINATION

- A. Notice: Provide 10 day notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air and hydronic systems have been satisfactorily completed. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous TAB results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.
 - 1. Duct pressure tested without duct accessories such as dampers and access doors installed is not valid.

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 systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices 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 supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- 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 filters and verify that bearings are greased, belts are aligned and tight, 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 three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine operating safety interlocks and controls on HVAC equipment.
- N. 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. PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures including a list of each piece of equipment and system.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Automatic temperature-control systems are operational.
 - 3. Equipment and duct access doors are securely closed.
 - 4. Balance, smoke, and fire dampers are open.
 - 5. Isolating and balancing valves are open and control valves are operational.
 - 6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 7. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3. GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in ASHRAE-111 and in this Section.
 - 1. Comply with requirements in ASHRAE-62.1, Section-7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to specifications.

- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4. VIBRATION TESTING

- A. Conduct vibration testing in accordance with the requirements of the AABC National Standards for Total System Balance. Testing shall occur after related systems have been balanced.
- B. Vibration testing shall be performed on the following equipment:
 - 1. Air handling equipment such as air handling units, rooftop units, dedicated outdoor air units, etc.
- C. Record and report test results. Equipment vibration severity rated between “good” and “extremely smooth” is acceptable unless otherwise noted. Where equipment does not meet the minimum standards, identify the source and recommend solutions to the Engineer.
 - 1. Equipment serving or located adjacent to performance spaces shall be rated between “very good” and “extremely smooth”.

3.5. GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.

- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified.

3.6. PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 - 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 - 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - 1. Measure airflow of submain and branch ducts.

- a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7. PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record final fan-performance data.
- B. Single-Zone, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 2. Set supply fan at minimum airflow if minimum airflow is indicated. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation.
 3. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 4. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 5. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.8. PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.

4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.9. PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.10. PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each refrigerant coil:
 1. Dry-bulb temperature of entering and leaving air.
 2. Wet-bulb temperature of entering and leaving air.
 3. Airflow.
 4. Air pressure drop.
 5. Refrigerant suction pressure and temperature.

3.11. TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent.

3.12. PRELIMINARY REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.13. FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Fan curves.
 - 2. Manufacturers' test data.
 - 3. Field test reports prepared by system and equipment installers.
 - 4. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB contractor.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the contract documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Fan drive settings including settings and percentage of maximum pitch diameter.
 - e. Settings for supply-air, static-pressure controller.
 - f. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Duct, outlet, and inlet sizes.
 3. Terminal units.
 4. Balancing stations.
 5. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.

- c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Number, type, and size of filters.
- 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Center-to-center dimensions of sheave, and amount of adjustment.
- 3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate.
 - b. Total system static pressure.
 - c. Fan rpm.
 - d. Discharge static pressure.
 - e. Filter static-pressure differential.
 - f. Cooling-coil static-pressure differential.
 - g. Heating-coil static-pressure differential.
 - h. Outdoor airflow.
 - i. Return airflow.
 - j. Outdoor-air damper position.
 - k. Return-air damper position.
- F. Apparatus-Coil Test Reports:
 - 1. Coil Data:

- a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing.
 - f. Make and model number.
 - g. Face area.
 - h. Tube size.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate.
 - b. Average face velocity.
 - c. Air pressure drop.
 - d. Outdoor-air, wet- and dry-bulb temperatures.
 - e. Return-air, wet- and dry-bulb temperatures.
 - f. Entering-air, wet- and dry-bulb temperatures.
 - g. Leaving-air, wet- and dry-bulb temperatures.
 - h. Refrigerant expansion valve and refrigerant types.
 - i. Refrigerant suction pressure.
 - j. Refrigerant suction temperature.
- G. Gas Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.

- d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Output capacity.
 - h. Ignition type.
 - i. Burner-control types.
 - j. Motor horsepower and rpm.
 - k. Motor volts, phase, and hertz.
 - l. Motor full-load amperage and service factor.
 - m. Sheave make, size and bore.
 - n. Center-to-center dimensions of sheave, and amount of adjustments.
2. Test Data (Indicated and Actual Values):
- a. Total air flow rate.
 - b. Entering-air temperature.
 - c. Leaving-air temperature.
 - d. Air temperature differential.
 - e. Entering-air static pressure.
 - f. Leaving-air static pressure.
 - g. Air static-pressure differential.
 - h. Low-fire fuel input.
 - i. High-fire fuel input.
 - j. Manifold pressure.
 - k. High-temperature-limit setting.
 - l. Operating set point.
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.

- o. Heating value of fuel.
 - H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate.
 - b. Total system static pressure.
 - c. Fan rpm.
 - d. Discharge static pressure.
 - e. Suction static pressure.
 - I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature.
 - d. Duct static pressure.

- e. Duct size.
 - f. Duct area.
 - g. Indicated air flow rate.
 - h. Indicated velocity.
 - i. Actual air flow rate.
 - j. Actual average velocity.
 - k. Barometric pressure.
- J. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area.
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate.
 - b. Air velocity.
 - c. Preliminary air flow rate as needed.
 - d. Preliminary velocity as needed.
 - e. Final air flow rate.
 - f. Final velocity.
 - g. Space temperature.

K. Instrument Calibration Reports:

1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.14. INSPECTIONS

A. Initial Inspection:

1. After testing and balancing is complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 10 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the contract documents in the final report.

B. Final Inspection:

1. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the engineer.
2. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
3. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
 1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, owner may contract the services of another TAB contractor to complete TAB work according to the contract documents and deduct the cost of the services from the original TAB contractor's final payment.
- D. Prepare test and inspection reports.

3.15. ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 DUCT INSULATION

PART 1 - GENERAL

1.1. SUMMARY

- A. Section includes insulation of indoor and outdoor supply, return, exhaust, relief and ventilation duct systems.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Samples: For each type of insulation and jacket indicated. Identify each sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 6 inches square.
 - 2. Sheet Jacket Materials: 6 inches square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3. QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
 - 2. Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.4. DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
- B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material, installed or not, that becomes wet, dirty, etc. shall be removed and replaced. "Dried" or "cleaned" insulation materials shall not be used.

1.5. COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields.
- B. Coordinate clearance requirements with duct installer for duct insulation application. Before preparing ductwork shop drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6. SCHEDULING

- A. Schedule insulation installation after pressure testing duct systems. Application may begin on segments that have satisfactory test results. Insulation applied prior to satisfactory test results shall be removed and replaced.

PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290. Provide Type II with factory-applied vinyl jacket; Type III with factory-applied FSK jacket; or Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. R-value requirements defined in Part 3 of this section as based on installed ratings with 25 percent compression.
- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ or FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2. ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.3. MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

2.4. SEALANTS

- A. Materials shall be compatible with insulation materials, jackets and substrates.
 1. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. FSK and Metal Jacket Flashing Sealants
- C. ASJ Flashing Sealants and Vinyl Flashing Sealants

2.5. FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6. FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd.

2.7. FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
 1. Adhesive: As recommended by jacket material manufacturer.
- C. Metal Jacket:
 1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Finish and thickness are indicated in field-applied jacket schedules.

- b. Moisture Barrier for Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
- c. Jacket shall have surface finish to accept paint.

2.8. TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

2.9. SECUREMENTS

- A. Insulation Pins and Hangers:
 - 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.
 - 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - 3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.

2.10. CORNER ANGLES

- A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 - EXECUTION**3.1. EXAMINATION**

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

3.2. PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3. GENERAL INSTALLATION REQUIREMENTS

- A. Insulate all components of duct systems as specified with the exception of the following components:
 - 1. Fibrous-glass ducts.
 - 2. Factory-insulated flexible ducts.
 - 3. Factory-insulated plenums and casings.
 - 4. Flexible connectors.
 - 5. Vibration-control devices.
 - 6. Factory-insulated access panels and doors.
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- C. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.

- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. 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 similar to butt joints.

3.4. PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

3.5. INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory-

or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6. FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7. FINISHES

- A. Paint duct insulation with ASJ, glass-cloth, or other paintable jacket material. Color shall be selected by the Owner/Engineer. Refer to Section 230553.
 - 1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.
 - 2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.
 - 3. Paint exposed aluminum jackets. Color shall be selected by the Owner/Engineer. Refer to Section 230553.
- B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.
- C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.

3.8. INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. General Building Duct Systems
 - 1. Concealed single-wall duct shall be insulated as follows:
 - a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket.
 - b. Return and Relief Air: 2-inches (R-6) of mineral fiber board.
 - c. General Building Exhaust Air: None.
 - 2. Exposed-to-view single-wall rectangular duct shall be insulated as follows:
 - a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber board.
 - b. Return and Relief Air: 2-inches (R-6) of mineral fiber board.
 - c. General Building Exhaust Air: None.
 - 3. Concealed or exposed-to-view double-wall duct shall have interstitial insulation as follows:
 - a. Supply and Ventilation Air: 2-inches of mineral fiber blanket.
 - b. Return and Relief Air: 2-inches (R-6) of mineral fiber board.
 - c. General Building Exhaust Air: None.
- B. Special Duct Systems
 - 1. Concealed or exposed-to-view single-wall duct shall be insulated as follows:
 - a. Clothes Dryer Exhaust Air: None.
- C. Plenums
 - 1. Plenums connected to outdoor louvers or hoods shall be insulated as follows:
 - a. Ventilation Air: 3-inches (R-8) of mineral fiber board.
 - b. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board.
 - 2. Plenums not connected directly to the outdoors shall be insulated as follows:

- a. Supply Air: 2-inches (R-6) of mineral fiber board.
 - b. Ventilation Air: 3-inches (R-8) of mineral fiber board.
 - c. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board.
3. Acoustic Plenums and Duct Silencers: Interior or interstitial duct liner shall have the same or greater thermal resistance as the systems they are attached as indicated above.

3.9. INDOOR FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. General Building Duct Systems
 1. Concealed single-wall insulated duct jacket: None.
 2. Exposed-to-view single-wall insulated duct jacket: 0.032-inch thick painted smooth aluminum.
- C. Special Duct Systems
 1. Concealed single-wall insulated duct jacket:
 - a. Clothes Dryer Exhaust Air: None.
 2. Exposed-to-view single-wall insulated duct jacket:
 - a. Clothes Dryer Exhaust Air: None.
- D. Plenums
 1. Single-wall insulated plenum jacket: 0.032-inch thick painted smooth aluminum.

END OF SECTION 230713

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SECTION 232113
HYDRONIC PIPING

PART 1 - GENERAL

1.1. SUMMARY

- A. Section includes pipe and fitting materials and joining methods for above ground hydronic piping.

1.2. ACTION SUBMITTALS

PART 2 - PRODUCTS

2.1. COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings and Unions: ASME B16.22.

2.2. JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

PART 3 - EXECUTION

3.1. PIPING APPLICATIONS

- A. Condensate Drain Piping:
 - 1. Copper Piping: Type DWV for 1 1/2-inch and larger piping and Type L for 1 1/4-inch and smaller piping, drawn-temper ("hard") copper tubing, wrought-copper fittings and soldered joints.

3.2. PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. 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 at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation.
- K. Install piping at a uniform grade of 0.2 percent downward in direction of flow.
- L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- M. Install unions in piping, 2-inch NPS and smaller at final connections of equipment, and elsewhere as indicated.
- N. Comply with requirements in Section 230553 for identifying piping.
- O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517.
- P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517.
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230100.

3.3. DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

3.4. HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 for seismic restraints.

3.5. PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads 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.
- F. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Non-Pressure Piping: Join according to ASTM D 2855.

3.6. FIELD QUALITY CONTROL

- A. Flush and pressure test piping to 10 feet of static head.

END OF SECTION 23 21 13

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SECTION 233113**METAL DUCTS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes single and double-wall round, oval and rectangular metal duct and fittings and associated duct liner, sealants, gaskets, hangers and supports.

1.2. PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE-62.1.

1.3. ACTION SUBMITTALS

- A. Product Data: For each type of duct liner, adhesives, sealants and gaskets.
- B. Shop Drawings: For all new ductwork and accessories.
 - 1. Factory- and shop-fabricated ducts and fittings.
 - 2. Reinforcement and spacing.
 - 3. Seam and joint construction.
 - 4. Details for penetrations through fire-rated and other partitions.
 - 5. Hangers and supports, including methods for duct and building attachment and vibration isolation.
 - 6. Sheet metal thicknesses.

1.4. INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling

1.5. CONSTRUCTION PROGRESS SUBMITTALS

- A. Leakage Test Report: Documentation of work performed for compliance with ASHRAE 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."

1.6. CLOSEOUT SUBMITTALS

- A. As-Built Documents: Provide revised coordination drawings to match the installed conditions.
- B. As-Built Documents: Provide revised construction drawings to indicate the installed conditions as part of the complete HVAC As-Built Drawing set. The as-built drawings shall be professionally drafted and noted so they are easily read by others.

PART 2 - PRODUCTS

2.1. GENERAL DUCT AND FITTINGS CONSTRUCTION REQUIREMENTS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class listed in Part 3, with the following exceptions:
 1. Minimum Sheet Metal Thickness:
 - a. Galvanized Sheet Steel: 0.0276-inches (24 gage).
 - b. Stainless Sheet Steel: 0.025-inches
 - c. Aluminum Sheet Metal: 0.020-inches
- B. General Cleanliness Requirements: Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines".
 1. Minimum Duct Cleanliness Level: C ("Advanced Level")

- a. Internal surfaces shall be wiped clean after fabrication prior to sealing for shipment.
 - b. Self-adhesive labels may be affixed to only the outside surfaces of the duct.
- C. Duct Dimensions: Dimensions in the construction documents indicate as follows:
 - 1. Rectangular Duct: Nominal inside width and height of the duct.
 - 2. Round Duct: Nominal inside diameter of the duct.
- D. Double-Wall Duct: For double-wall duct, the inside is defined as the inner-duct.
- E. Rectangular Ducts shall comply with the following standards:
 - 1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 3. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Double-Wall Duct: Double-wall rectangular ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.
 - a. Interstitial Insulation: Comply with Section 230713
 - b. Minimum Thermal Resistance: Comply with Section 230713
 - c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - d. Coat insulation with antimicrobial coating.
 - e. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

G. Round Ducts shall comply with the following standards:

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60-inches diameter: Flanged.
2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 84-inches diameter with butt-welded longitudinal seams.
3. Spiral Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Round Duct Spiral Seams, for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 84-inches diameter with butt-welded longitudinal seams.
4. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
5. Double-Wall Duct: Double-wall round and flat-oval ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.
 - a. Interstitial Insulation: Comply with Section 230713
 - b. Minimum Thermal Resistance: Comply with Section 230713
 - c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - d. Coat insulation with antimicrobial coating.
 - e. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

2.2. SHEET METAL MATERIALS

- A. General Material Requirements: 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 shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation:
 - a. Indoor Applications: G60.
 - b. Outdoor Applications: G90.
 - 2. Finishes for Surfaces Exposed-to-View: Mill phosphatized.
 - 3. Finishes for Surfaces Exposed-to-View: Painted.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316 or 304, cold rolled, annealed, sheet. Exposed surface finish shall be No.4.
- D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3. DUCT LINER

- A. Duct liner shall only be used for return air transfer ducts and boots.
- B. Thermal Properties:
 - 1. Minimum Thermal Resistance: R-3.5 (indoor applications)
 - 2. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - 5. Insulation Pins and Washers:

6. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
7. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick aluminum with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
8. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
9. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
10. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
11. Butt transverse joints without gaps, and coat joint with adhesive.
12. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
13. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
14. Apply adhesive coating on longitudinal seams.
15. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
16. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

2.4. SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.

4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.5. HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- G. 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. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts according to SMACNA's "Duct Cleanliness for New Construction Guidelines".
 - 1. Store duct, fittings and accessories on pallets in a clean and dry location.

2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place.
 3. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating.
- D. Install round ducts in maximum practical lengths.
 - E. Install ducts with fewest possible joints.
 - F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
 - G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
 - H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
 - I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
 - J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
 - K. 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.
 - L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements of the specifications for fire and smoke dampers.
 - M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. 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 the 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. ADDITIONAL INSTALLATION REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

- A. Install duct in accordance the manufacturer's recommended installation instructions whichever they are more stringent.
- B. Provide an accessible cleanout at each vertical riser. Provide a minimum 12-inch by 12-inch access door to access the cleanout where needed. Coordinate the exact location with the Engineer.
- C. Provide a factory-fabricated aluminum dryer vent termination with an integral backdraft damper at the exterior termination. Bird and insect screens are not acceptable.
- D. Support duct from building structure at minimum 4-foot on-center.
- E. Provide a temporary cap on the interior duct opening until the clothes dryer is installed.
- F. Provide protective galvanized steel shield plates, minimum 0.062-inches thick, to prevent penetrations of the duct. Locate shield plates on the finish face of all framing members where there is less than 1.5-inches between the duct and the finish face of the framing member. Shield plates shall extend 2-inches above sole plates and below top plates.
- G. Transition ducts shall not be concealed by the building construction. Transition ducts shall be listed and labeled for their application and be no more than 8-foot long.

3.4. HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 10 feet.
- F. 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.

3.5. CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6. PAINTING

- A. Paint interior of all metal duct that is visible through registers and grilles and that does not have duct liner.
- B. Paint exterior of all galvanized metal duct that is exposed-to-view. Do not paint stainless steel duct unless otherwise directed.
1. Exception: Do not paint duct in mechanical rooms, mezzanines or penthouses.
- C. Painting Duct:
1. Clean duct of dirt, grease and lubricants with a non-hydrocarbon "green" cleaner.
 2. Prime duct with 2 coats of water-based white acrylic primer paint designed for use with galvanized steel.
 3. Finish duct with 2 coats of latex paint.

- a. Exterior Duct Surfaces: Color and finish shall be chosen by the owner/architect.
- b. Interior Duct Surfaces: Flat black.
- D. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.
- E. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.
- F. Mill phosphatized or galvannaeeled "paint grip" steel is not acceptable.

3.7. FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Pressure Tests:
 - 1. Test 100% of supply, return, exhaust, relief and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.
 - a. If approved by the Engineer, based on a visual inspection of the duct installation and sealant application, the following low pressure (2-inches wg or less) duct will not require leakage testing. Poor workmanship as judged by the Engineer will result in leakage testing of exempted duct.
 - 1) Return air duct for a return plenum systems under negative pressure and less than 30 ft. total length of duct.
 - 2) Return air duct from the intake of fan coil units and blower coil units under negative pressure and less than 30 ft. total length of duct.
 - 3) Exhaust air duct under negative pressure and less than 30 ft total length of duct.
 - 4) Ventilation air duct under negative pressure and less than 30 ft. total length of duct.
 - 5) Supply air duct from the discharge of terminal units, fan coil units and blower coil units under positive pressure and less than 30 ft. total length of duct.
 - 2. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21 and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter 19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 4. Test for leaks before applying external insulation.
 5. Provide 10 day notice for testing.
 6. Testing performed prior to the installation of duct accessories, such as dampers and access doors, is not valid. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.
- C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8. DUCT SCHEDULE

- A. Fabricate ducts to the requirements indicated.
1. Low Pressure Air Systems: Applies to general building return, exhaust, ventilation and relief air duct; and supply air duct downstream from constant volume air handlers and terminal units.
 - a. Construction: Single-wall galvanized sheet steel when concealed or exposed to view in mechanical spaces. Double-wall galvanized sheet steel when exposed to view in occupied spaces or otherwise indicated.
 - 1) Round / oval single-wall duct shall have longitudinal or spiral seams and double-wall shall have spiral seams.
 - b. Static Pressure Class: 2-inches w.g.
 - c. SMACNA Seal Class: B
 - d. SMACNA Leakage Class: 8
 2. Clothes Dryer Exhaust Air:

- a. Construction: Single-wall aluminum sheet, minimum 0.020-inch thick and minimum 4-inches diameter, with a smooth interior finish and longitudinal seams.
- b. Static Pressure Class: 2-inches w.g.
- c. SMACNA Seal Class: B
- d. SMACNA Leakage Class: 8
- 3. Double-Wall Duct Interstitial Insulation:
 - a. Supply Air Ducts: 2-inches thick.
 - b. Return Air Ducts: 2-inches thick.
 - c. Exhaust Air Ducts: None.
- B. Elbow Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE-1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE-3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE-2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - b. Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - c. Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - d. Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - e. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - f. Round Elbows, 14 Inches and Larger in Diameter: Welded

C. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round : Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity up to 1500 fpm: Conical tap.
 - b. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

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SECTION 233300**METAL DUCT ACCESSORIES****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes air duct accessories including relief, volume, control and life-safety dampers; flexible ducts; flange and flexible connectors; turning vanes; duct silencers; duct-mounted access doors; and duct hardware.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.3. CLOSEOUT SUBMITTALS

- A. Life-Safety Damper Inspection Reports: Document testing and results for all life-safety dampers including installation and operation inspection, engineer's inspections and AHJ's inspections.
- B. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4. 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.

PART 2 - PRODUCTS**2.1. ASSEMBLY DESCRIPTION**

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. 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 shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2. MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3. GRAVITY BALANCED BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Description: Gravity-balanced dampers for backdraft or pressure relief. Dampers shall have adjustable tension return spring; steel ball bearings; counter-weights and spring-assist kits for vertical flow applications; and bird screens. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2-inches w.g. maximum system pressure.
 - 1. Frame: Hat-shaped with welded corners or mechanically attached and mounting flange, constructed of one of the following to match the duct system material type for each: 12-gauge thick, galvanized sheet steel; 0.063-inch thick extruded aluminum; or 0.05-inch thick stainless steel.
 - 2. Blades: Parallel-action, multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with mechanically-locked neoprene blade seals and 0.20-inch diameter stainless steel blade axles.

2.4. MANUAL VOLUME DAMPERS

- A. Standard Rectangular, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 2000 fpm

maximum air velocity and 2.5-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MD35.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.
 2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 8-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.
- B. Standard Round, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 1500 fpm maximum air velocity and 2-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MDRS25
1. Frame: Constructed of 20-gauge thick galvanized sheet steel, flangeless for in duct installations.
 2. Blades: Single-blade, center-pivot, 20-gauge thick galvanized sheet steel, 0.375-inch diameter galvanized steel blade axle and 90-deg quadrant handle. Provide 2-inch handle extension wherever duct system will be insulated.
- C. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include elevated platform for insulated duct mounting.
1. Handle operation shall be painted orange.

2.5. CONTROL DAMPERS

- A. Standard Rectangular, Steel, Control Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity, 2.5-inches w.g. maximum system pressure and maximum leakage of 10 cfm/sqft. at 1.0-inches pressure. Provide dampers equivalent to Ruskin CD35.
1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.
 2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 6-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.
- B. Standard Round and Oval, Steel, Control Dampers: Standard rating suitable for horizontal or vertical volume control applications with molded synthetic bearings.

Unless otherwise indicated, dampers shall be rated for 2500 fpm maximum air velocity, 4.0-inches w.g. maximum system pressure and maximum leakage of 10 cfm/sqft. at 1.0-inches pressure. Provide dampers equivalent to Ruskin CDR25 (round) / CDO25 (oval).

1. Frame: Constructed of 14-gauge thick galvanized sheet steel, either with flanges on both sides or internal duct mounting.
 2. Blades: Single-blade action, 12 gauge-thick steel, center-pivot, closed cell rubber edge seals and galvanized steel blade axles.
- C. Low-Leakage Rectangular, Steel, Control Dampers: Low-leakage rating suitable for horizontal or vertical volume control applications with stainless steel bearings. Unless otherwise indicated, dampers shall be rated for 3000 fpm maximum air velocity, 3.0-inches w.g. maximum system pressure and maximum leakage of 3 cfm/sqft. at 1.0-inches pressure. Dampers shall be AMCA Class 1A rated. Provide dampers equivalent to Ruskin CD60.
1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.
 2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 6-inch width, 14-gauge thick galvanized steel, closed-cell rubber edge seals, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.
- D. Low-Leakage Round, Steel, Control Dampers: Low-leakage rating suitable for horizontal or vertical volume control applications with stainless steel bearings. Unless otherwise indicated, dampers shall be rated for 4000 fpm maximum air velocity, 6.0-inches w.g. maximum system pressure and maximum leakage of 0.15 cfm/inch perimeter. at 4.0-inches pressure. Provide dampers equivalent to Ruskin CDRS25.
1. Frame: Constructed of 20-gauge thick galvanized sheet steel, either with flanges on both sides or internal duct mounting.
 2. Blades: Single-blade action, 14 gauge-thick steel, center-pivot, closed cell rubber edge seals and galvanized steel blade axles.

2.6. TURNING VANES

- A. Turning Vanes for Metal Ducts: Factory-fabricated, double-wall, curved airfoil-shaped blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting. Comply with details in SMACNA "HVAC Duct Construction Standards – Metal and Flexible"

2.7. REMOTE DAMPER OPERATORS

- A. Manual Cable Type Remote Damper Actuator: Cable system designed for remote manual damper adjustment. Cable system shall consist of steel cable within aluminum tubing at lengths required from damper actuator to access point. External cable system shall have recessed galvanized steel back-box at wall or ceiling termination for removable wrench or screwdriver actuation. Internal cable system shall terminate behind the diffuser or grille face and be accessible through its face.
- B. Provide die cast ceiling cup with cover plate at hard gypsum board ceilings. Cover plate shall match ceiling color selected by architect. For slat type ceiling systems with an interstitial gap, provide controller mounted above the slat ceiling with attachment to the slat ceiling system. Removable wrench or screwdriver actuation shall access the operator through the interstitial gap. Provide multi-port balancing station for multiple dampers.

2.8. DUCT-MOUNTED ACCESS DOORS

- A. General: Factory-fabricated access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - 1. Doors: Double wall, minimum 20-gauge galvanized sheet metal with 1-inch mineral fiber or foam insulation fill and thickness and be air-tight suitable for duct pressure and leakage classification.
 - a. Rectangular Duct-Mounted Access Doors: Rectangular and square access doors for rectangular and oval duct.
 - 1) Door Sizes: 6-inch square access doors shall be used in 8-inch largest dimension ducts; 8-inch square doors in up to 12-inch ducts; 12-inch square doors in up to 20-inch ducts; 18-inch square doors in up to 28-inch ducts; and 24-inch square doors in 30-inch and larger ducts.
 - b. Plenum Access Doors: Open outward for positive-pressure ducts and inward for negative-pressure ducts. Full height plenums shall have 72-inch tall x 30-inch wide door with vision panel and mounted at minimum 4-inches above the floor unless otherwise indicated.
 - 2. Frames: Galvanized sheet steel, with bend-over tabs and foam or neoprene gaskets. Security chain to restrain door to frame.
 - 3. Hinges and Latches: 1-inch x 1-inch butt or piano hinge or cam latches. Doors 12-inches square or smaller shall have minimum 2 cam latches; 18-inches square or smaller, 4 cam latches; 24-inches square or smaller, 2 hinges or continuous piano hinge and 2 cam latches; 24-inches x 48-inches or smaller, 3 hinges or continuous piano hinge and 2 cam latches; and larger than 24-inches x 48-inches, continuous piano hinge and 3 cam latches.
- B. Stainless steel duct: Access doors and frames in stainless steel duct shall be constructed of stainless steel to match.

- C. Access doors must be installed prior to duct pressure and leakage testing. If the Engineer determines the access doors cannot meet the requirements of the testing, they shall be replaced with a higher quality door at the contractor's expense.

2.9. FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene with a minimum weight of 26 oz/sqyd; tensile strength of 480 lbf/inch in the wrap and 360 lbf/inch in the filling; and a service temperature range of (-) 40 deg F to 200 deg F.
- E. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct. They shall be factory-fabricated for HVAC applications up to 10-inches w.g. of pressure.
- F. Grounding Straps: Flexible braided copper grounding strips, flat or round, providing an equivalent ampacity of a #6 AWG conductor.

2.10. FLEXIBLE DUCTS

- A. General: Flexible duct shall comply with UL 181, Class 1 and have flame spread rating of less than 25 and smoke developed rating of less than 50.
- B. Noninsulated, Flexible Duct: Aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 20 deg F to 210 deg F.
- C. Insulated, Flexible Duct: Double-ply polyester film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 10 deg F to 160 deg F. Insulation value shall meet or exceed R-value of connected duct insulation.
- D. Flexible Duct Connectors: Stainless steel bands with cadmium-plated hex screws to tighten band with a worm gear action sized to suit duct size.

2.11. DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- 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 control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Whether or not indicated on plans, 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. Damper construction materials shall match duct system materials.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, 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.

7. Upstream from turning vanes.
 8. Upstream or downstream from duct silencers.
 9. Control devices requiring inspection.
 10. Elsewhere as indicated.
- H. Install access doors with swing against duct static pressure.
- I. Label access doors according to Section 230553 to indicate the purpose of access door.
- J. Install flexible connectors to connect ducts to equipment. Install flexible grounding strip(s) from equipment to duct.
- K. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- L. Connect terminal units to supply ducts maximum 6-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- M. Connect diffusers or light troffer boots to ducts with maximum 6-foot lengths of flexible duct clamped or strapped in place, unless otherwise indicated.
- N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws and tape.
- O. Install duct test holes where required for testing and balancing purposes.
- P. 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.

3.2. CONTROL DAMPERS

- A. Control Dampers for Air Handling Equipment:
1. Outside Air (OA) Dampers: Opposed-blade type sized for 2,000 FPM face velocity at full flow and 100 FPM at 5-percent flow.
 2. Relief Air (RelA) / Exhaust Air (EA) Dampers:
 - a. Fan: Opposed-blade type sized for 2,000 FPM face velocity at full flow.
 - b. Barometric: Parallel-blade type sized for 1,000 FPM face velocity at full flow.

3. Return Air (RA) Dampers: Parallel-blade type sized for 1,500 FPM face velocity at full flow.

3.3. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Inspect turning vanes for proper and secure installation.
4. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

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SECTION 233416**HVAC EQUIPMENT FANS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes airfoil centrifugal, backward-inclined centrifugal, forward-curved centrifugal, plenum and plug fans for use in air system equipment such as air handling and rooftop units.

1.2. ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each fan; certified fan performance curves with system operating conditions indicated; certified fan sound-power ratings; motor ratings and electrical characteristics, plus motor and electrical accessories; material thickness and finishes; and dampers, including housings, linkages, and operators.

1.3. CLOSEOUT SUBMITTALS

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

1.4. 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.

PART 2 - PRODUCTS**2.1. GENERAL REQUIREMENTS**

- A. Description: Factory fabricated, assembled, tested, and finished, and direct-driven (as scheduled) centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly and support structure with factory installed and wired service disconnect switch. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
- B. AMCA Compliance: Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal. Classify operating limits according to AMCA 99.

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
 2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2. CENTRIFUGAL FANS

- A. Housings: Horizontally-split, bolted-flange curved-scroll housing with shaped cutoff, flanged spun inlet cone and flanged outlet. Panel Bracing shall be steel angle or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
- B. Centrifugal Fan Wheels:
1. Airfoil Wheels: Fan wheels shall be single-width single-inlet (SWSI) and double-width double-inlet (DWDI) construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
 2. Backward-Inclined Wheels: Fan wheels shall be single-width single-inlet (SWSI) and double-width double-inlet (DWDI) construction with curved inlet flange; backplate; backward-inclined blades; fastened to shaft with set screws; and cast-iron or cast-steel hub riveted to backplate welded or riveted to flange and backplate.
 3. Forward-Curved Wheels: Fan wheels shall be black-enameled or galvanized-steel construction with inlet flange; backplate; shallow blades with inlet and tip curved forward in direction of airflow; cast-steel hub swaged to backplate and fastened to shaft with set screws; and mechanically secured to flange and backplate.
- C. Plenum Fan Wheels: Airfoil wheel shall be single-width single-inlet (SWSI) construction with heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- D. Plug Fan Wheels: Airfoil wheel shall be single-width-single-inlet (SWSI) construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

- E. Shafts: Fan shafts shall be statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment. Shafts shall be turned, ground, and polished hot-rolled steel with keyway and finished with an anti-corrosive coating. They shall be designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- F. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block type bearings rated for L10 at 100,000 hours.
- G. Accessories:
 - 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 - 2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
 - 3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - 4. Inlet Screens: Grid screen of same material as housing.
 - 5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - 6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
 - 7. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3. MOTORS

- A. Motors: Comply with requirements of Section 230513.
 - 1. Shaft Grounding Rings (SGR): Fan motors 20 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.
- B. Speed Controller: Where indicated, provide solid-state, factory-mounted, variable speed controller on 115V or 230V single-phase, direct-drive fans for air flow balancing.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Install centrifugal fans level and plumb.

- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices.
 - 1. Comply with requirements in Section 233300 for flexible duct connectors.
 - 2. Comply with requirements in Section 230548 for vibration and seismic devices.
- E. Install units with clearances for service and maintenance.

3.2. CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300.
- B. Install ducts adjacent to fans to allow service and maintenance.

3.3. FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust damper linkages for proper damper operation.
 - 6. Verify lubrication for bearings and other moving parts.
 - 7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 8. See Section 230593 for testing, adjusting, and balancing procedures.

9. Remove and replace malfunctioning units and retest as specified above.

3.4. DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

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SECTION 233423**HVAC SYSTEM FANS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes centrifugal roof ventilators and ceiling-mounted ventilators.

1.2. PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.3. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. The product data shall also include the following: certified fan performance curves with system operating conditions indicated; certified fan sound-power ratings; motor ratings and electrical characteristics, plus motor and electrical accessories; material thickness and finishes; dampers, including housings, linkages, and operators; roof curbs; and fan speed controllers.

1.4. CLOSEOUT SUBMITTALS

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

1.5. MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS**2.1. GENERAL REQUIREMENTS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Greenheck Fan Corp.

2. Loren Cook Company
 3. PennBarry
 4. Twin City Fan and Blower
- B. Description: Factory fabricated, assembled, tested, and finished, direct-driven (as scheduled) fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly and support structure with factory installed and wired service disconnect switch. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
- C. AMCA Compliance: Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal. Classify operating limits according to AMCA 99.
1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
 2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."
- D. Shafts: Fan shafts shall be statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment. Shafts shall be turned, ground, and polished hot-rolled steel with keyway and finished with an anti-corrosive coating. They shall be designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- E. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block type bearings rated for L10 at 100,000 hours.
1. Extend grease fitting to accessible location outside of unit.
- F. Direct Drives: Factory-mounted with 1.2 service factor based on fan motor.
- G. Motors: Comply with requirements of Section 230513.
1. Shaft Grounding Rings (SGR): Fan motors 20 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.
- H. Speed Controller: Where indicated, provide solid-state, factory-mounted, manual speed controller on 115V or 230V single-phase, direct-drive fans for air flow balancing.

- I. 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.
 - 1. Disconnect Switch: Factory wired and mounted non-fusible type with thermal-overload protection mounted to the fan housing, unless otherwise indicated. Wiring shall be enclosed in aluminum conduit.
- J. Dampers: Motor-operated, parallel blade aluminum dampers mounted in the curb base shall open when the fan starts and close when it stops. Refer to Section 233300.
 - 1. Where indicated, provide counter-balanced backdraft dampers in lieu of motor-operated type.
- K. Roof Curbs: Factory-fabricated welded-seam self-flashing roof curb to match fan and roof-slope, constructed of galvanized sheet metal with 1 1/2-inch pressure-treated wood nailer, water-tight gasket, 1 1/2-inches of rigid fiberglass insulation, damper tray, and finished with primer and powder baked white enamel.
 - 1. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match exhaust fan, used to anchor unit to the curb, and designed for loads at project site. Comply with requirements in Section 230548.
 - 2. Curb Height: 16-inches with a minimum of 12-inches above the finished roof surface.

2.2. CENTRIFUGAL ROOFTOP FANS

- A. General Description: Rooftop fan with removable spun-aluminum dome top and outlet baffle; square one-piece aluminum base with venture inlet cone; fan wheel with aluminum hub and wheel with backward-inclined blades; direct-drive as scheduled. Outlet shall have removable 1/2-inch aluminum mesh birdscreen.
- B. Rooftop Dome-Type Downblast Centrifugal Fans: Greenheck G Series, Loren Cook ACE Series, PennBarry Domex DX Series or Twin City DCRD Series.
 - 1. Application: General building exhaust systems.
 - 2. Corrosion Resistance Coating: Baked white epoxy powder coating with UV protection.

2.3. CABINET FANS

- A. General Description: Cabinet style fan with steel housing lined with acoustical insulation; removable centrifugal fan wheel; direct-drive as scheduled. Electrical connection shall be hard-wired. Cord and plug wiring is not acceptable unless specifically noted on the equipment schedule.

- B. Ceiling Cabinet Fan: Provide fan with white painted aluminum ceiling grille; plastic grilles are not acceptable. When located in fire-rated ceiling assemblies, provide with ceiling radiation damper that complies with Section 233300. Greenheck CSP/SP Series, Loren Cook Gemini Series, PennBarry Zephyr Series or Twin City TL/DB Series.
 - 1. Applications: General exhaust air systems.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548.
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Section 230553.

3.2. CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300.
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Ground equipment according to Division 26.
- D. Connect wiring according to Division 26.

3.3. FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust damper linkages for proper damper operation.
 6. Verify lubrication for bearings and other moving parts.
 7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 8. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 9. Shut unit down and reconnect automatic temperature-control operators.
 10. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Prepare test and inspection reports.

3.4. ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 for testing, adjusting, and balancing procedures.
- C. Replace fan and motor pulleys as required to achieve design airflow.
- D. Lubricate bearings.

END OF SECTION 233423

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SECTION 233713**DIFFUSERS, REGISTERS, AND GRILLES****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes duct, ceiling, wall and floor-mounted air inlets and outlets.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.3. QUALITY ASSURANCE

- A. Comply with NFPA 90A and NFPA 90B.
- B. Install flexible diffusion ("fabric") outlets in accordance with manufacturer's recommendations.

1.4. WARRANTY

- A. Special Warranty: Manufacturer's warranty to repair or replace all components of the flexible diffusion outlets and hanging system for 5-years from the date of substantial completion.

PART 2 - PRODUCTS**2.1. METAL DIFFUSERS, GRILLES & REGISTERS**

- A. Manufacturers: Provide products that comply with the construction documents and are manufactured by one of the following, unless otherwise noted in this section:
 - 1. Krueger
 - 2. Nailor Industries

3. Price
 4. Titus
 5. Tuttle & Bailey
- B. General Requirements: Devices shall be specifically designed for variable air volume flows. Insulate backpan. Border type shall match each installation. Ceiling, wall, sill or duct-mounting as indicated. Face and neck dimensions as indicated. Inside of each backpan and duct plenum shall be painted flat black so that there is no visible metal from the face.
- C. Materials: Provide devices constructed of the following materials unless otherwise indicated.
1. Material: Steel, aluminum, or stainless steel as noted.
 2. Finish: Baked enamel, anodized aluminum, or primed-for-paint as noted.
 - a. Color: White, unless otherwise noted.
- D. Volume Dampers: Provide manual volume damper at each air inlet or outlet branch duct tap, whether shown on the drawings or not, regardless of the diffuser, grille or register having an integral damper unless specifically noted otherwise. Dampers shall comply with Section 233300.
- E. Fire-Rated Ceiling Assemblies: Provide UL-listed devices designed for integral use in fire-rated assembly ceilings. Do not use the fire damper blades to balance air flow unless specifically noted otherwise. Refer to Section 233300 for additional ceiling radiation fire damper requirements.

2.2. SUPPLY AIR DIFFUSERS

- A. Square Plaque Face Ceiling Diffuser: Plaque face diffuser with 360-degree discharge pattern, equalizing grid and foam rubber gasket. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus OMNI Series or equal.
- B. Standard Blade Grille: Double-deflection, adjustable, standard blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 45-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus 300 Series or equal.
- C. Linear Slot Ceiling Diffuser: Linear slot diffuser with 180-degree adjustable aluminum pattern controllers. The diffusers shall be of the length, number of slots and width of slots as indicated. Provide in continuous lengths and with insulated low profile duct plenums, blank-offs, T-bars clips, internal insulation and mitered corners to match the installation requirements. Titus ML Series or equal.

2.3. RETURN, EXHAUST AND TRANSFER AIR GRILLES AND REGISTERS

- A. Square Perforated Face Ceiling Grille: Perforated flush face grille with equalizing grid, foam rubber gasket and pre-formed insulation blanket. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus PAR Series or equal.
- B. Airfoil Blade Grille: Single-deflection, fixed, airfoil blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 35-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 3/4/23/25/55/56 Series or equal.
- C. Standard Blade Grille: Single-deflection, fixed, standard blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 35-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 350 Series or equal.

2.4. SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles 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, registers, and grilles are to be 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. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
- D. Diffusers, registers and grilles shall be supported at two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support lay-in ceiling track.

3.3. ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 23 41 00**PARTICULATE AIR FILTRATION – STANDARD EFFICIENCY****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes standard efficiency pleated panel, rigid cell box, bag and V-bank cell filters; bulk filter media; filter frames and housings; and filter gages.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. 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. 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. Provide two (2) complete set(s) of filters for each filter bank.

1.4. QUALITY ASSURANCE

- A. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- B. Comply with NFPA 90A and NFPA 90B.

PART 2 - PRODUCTS**2.1. GENERAL REQUIREMENTS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Airguard
 - 2. American Air Filter (AAF)
 - 3. Camfil (Farr)

4. Flanders
- B. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.2. PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, UL 900 Class 2, disposable air filters with holding frames. Media shall be interlaced glass or synthetic fibers coated with non-flammable adhesive. Filter-media frame shall be cardboard sealed or bonded to the media.
 1. 2-inch, MERV-8 with maximum initial resistance of 0.25-inches w.g. at 500 fpm and 0.15-inches w.g. at 300 fpm.
 2. 1-inch, MERV-8 with maximum initial resistance of 0.45-inches w.g. at 500 fpm and 0.25-inches w.g. at 300 fpm.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. 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.
- D. Coordinate filter installations with duct and air-handling-unit installations.

3.2. CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

SECTION 236213**PACKAGED ROOFTOP UNITS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes packaged rooftop style units.

1.2. PERFORMANCE REQUIREMENTS

- A. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of $L/200$ where "L" is the unsupported span length within completed casings.

1.3. ACTION SUBMITTALS

- A. Product Data: For each air-handling unit indicated, provide unit dimensions and weight; cabinet material, metal thickness, finishes, insulation, and accessories; certified fan-performance curves with system operating conditions indicated; certified fan-sound power ratings; fan construction and accessories; motor ratings, electrical characteristics, and motor accessories; certified coil-performance ratings with system operating conditions indicated; dampers including housings, linkages, and operators; and filters with performance characteristics.

1.4. INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved: mechanical equipment layout and relationships between components and adjacent structural, electrical and mechanical elements; support location, type, and weight; and field measurements.

1.5. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged rooftop units to include in emergency, operation, and maintenance manuals.

1.6. COORDINATION

- A. Package Rooftop Unit manufacturer is responsible for coordination of package controls with building control system contractor.

- B. Coordinate sizes, weights (operational and shipping) and locations of supports and opening with the actual equipment provided, including:
 - 1. Concrete bases
 - 2. Structural steel support members
 - 3. Roof curbs
 - 4. Roof/floor openings

1.7. WARRANTY

- A. Warranty: Parts and labor warranty of 1 year for the entire unit; 3 years for the control board; and 5 years for the compressors from the date of substantial completion.

1.8. 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. Filters: Two set(s) for each packaged rooftop unit.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide product by one of the following:
 - 1. Electric Cooling with Gas Heating, 3 to 10 tons:
 - a. Carrier (WeatherMaker series).
 - b. Daikin/McQuay (Maverick I series).
 - c. Trane Company (Precedent series).

2.2. GENERAL

- A. Description: Packaged heating and cooling units specifically designed for outdoor installation on a roof curb or concrete pad and completely factory-assembled and tested. All units shall be UL approved and comply with seismic requirements.

2.3. UNIT CASINGS

- A. Casing Fabrication (25 tons and smaller): Factory-fabricated and constructed wall, roof and floor single-wall galvanized steel casing panels with 1/2-inch (R-4) closed-cell insulation with foil-faced interior finish and sealed edges within formed galvanized steel channel framing. No through-metal casing thermal breaks. All joints shall be water-resistant sealed.
- B. Casing Finish: Factory-applied prime-coat and thermosetting top-coat enamel rated for a minimum of 500 hours consecutive salt-spray test per ASTM B117.
- C. Access Doors: Factory-fabricated double wall, to match casing and insulation materials, finish and performance and suitable for unit pressure and leakage classification.
 - 1. Door Hinges, Latches and Handles: Minimum of two ball-bearing or piano hinges, two wedge-lever latches and steel quarter-turn handles.
 - 2. Door Gaskets: Neoprene gasket around entire perimeter of door frames.
- D. Condensate Drain Pans: Factory-fabricated, insulated, stainless steel, water-tight sealed, minimum 2-inches deep drain pans sloped in two directions to collect condensate from cooling coils (including coil piping connections, coil headers and return bends) and humidifiers and direct water toward drain connection. Pan shall extend downstream of coil face to comply with ASHRAE 62.1. Drain connection shall be on the bottom side and at the lowest point on the pan. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- E. Base Rails: Galvanized or stainless steel rails, to match the exterior casing material, for mounting on roof curb or pad as indicated.
- F. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.
- G. Roof Curbs: Full-perimeter solid bottom acoustical curb of sheet metal, minimum 14 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing. Comply with requirements in "The NRCA Roofing Manual."
- H. Intake and Discharge Hoods: Factory-fabricated, galvanized steel intake and discharge weather hoods with bird screen and finish to match unit casing.
- I. Intake and Discharge Louvers: Galvanized steel intake and discharge louvers with bird screen and finish to match unit casing. Louvers shall be rated for the beginning of water penetration of 0.01 ounce/sqft. free area at 1000 fpm or higher.

2.4. FAN, DRIVE AND MOTOR SECTION

- A. Unit shall be equipped with supply, return and exhaust / relief air fans and capable of control functions as indicated.
- B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Shafts shall be designed for continuous operation at maximum-rated fan speed and motor

- horsepower, and with field-adjustable alignment. Fans shall be variable speed for single zone VAV operation.
- C. Centrifugal Fan Housings: Formed and reinforced steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell. Attach housing to fan-section casing with metal-edged flexible duct connector complying with Section 233300.
 - D. Fan Wheels:
 - 1. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
 - E. Fan Shaft Bearings:
 - 1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings, L50 rated for 200,000 hours with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.
 - 2. Motor Pulleys: Adjustable pitch for use with 5 hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - F. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
 - G. Motors: Comply with requirements of Section 230513.
 - 1. Shaft Grounding Rings (SGR): Fan motors 20 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.

2.5. REFRIGERATION SYSTEM

- A. Description: Factory assembled and tested, air cooled; consisting of compressors, condenser coils, condenser fans and motors, and controls.
- B. Compressor: Direct-drive, hermetic scroll-type compressors designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
 - 1. Capacity Control: Variable speed compressor for capacity control with continuous dehumidification on a single compressor.
- C. Refrigerant: R-407C, R-410A, or R-134A.

- D. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including sub-cooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant. Provide with condenser coil hail guard and factory-applied corrosion resistant coating rated for a minimum of 5,000 hours consecutive salt-spray test per ASTM B117.
- E. Condenser Fans: Propeller-type vertical discharge; direct-driven, variable speed, permanently lubricated, ball-bearing motors for each fan, dynamically and statically balanced fan assemblies.
- F. Operating and Safety Controls:
 - 1. Manual-reset, high-pressure cutout switches.
 - 2. Automatic-reset, low-pressure cutout switches.
 - 3. Low-oil-pressure cutout switch.
 - 4. Compressor-winding thermostat cutout switch.
 - 5. Three-leg, compressor-overload protection.
 - 6. Magnetic contactors for compressor and condenser fan motors.
 - 7. Timer to prevent excessive compressor cycling.
- G. Low-Ambient Controller: Controls condenser fan to permit operation down to 0 deg F with time-delay relay to bypass low-pressure switch.

2.6. GAS HEAT EXCHANGER

- A. Description: Factory-assembled, piped and wired gas-fired heat exchanger and burner, UL approved, and complying with the requirements of NFPA 54. Heat exchanger shall be tubular two-pass stainless steel factory pressure and leak tested. Burner shall be stainless steel with an air proving switch. Ignition shall be electronically controlled electric spark with flame sensor. Burner assembly shall house ignition and monitoring electrode. Combustion blower shall be centrifugal fan with motor with built-in thermal overload protection. Heat exchanger shall have a stainless steel drain pan.
- B. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 1. Gas Control Valve: Full modulating, condensing type, with a minimum turndown of 10:1.
- C. Combustion Efficiency: Minimum 80 percent.

- D. Venting: Power vented with integral, motorized centrifugal fan interlocked with gas valve.
- E. Safety Controls:
 - 1. Vent Flow Verification: Differential pressure switch to verify open vent or flame rollout switch.
 - 2. High Limit: Thermal switch or fuse to stop burner.
 - 3. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - 4. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
 - 5. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - 6. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.7. HEATING AND COOLING COILS

- A. Heating and Cooling Coils: Provide coil types in positions indicated. Comply with requirements of Section 238216. Coils shall comply with AHRI 410.

2.8. AIR FILTRATION SECTION

- A. Filters: Filter sections shall be designed for the indicated filter types and orientations. Where not indicated, provide housings and frames for angled 2-inch deep filters.
- B. Filter Holding Frames: Provide filter holding frames arranged for flat or angled orientation, with access doors on both sides of unit. Filters shall be removable from either side.

2.9. DAMPERS

- A. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, aluminum dampers mechanically fastened to cadmium-plated steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
- B. Isolation Dampers: Refer to Section 233300.
- C. Leakage Rate: Damper leakage rate shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential based on AMCA 500.

- D. Damper Operators: Comply with requirements in Section 230900.

2.10. ELECTRICAL SYSTEM

- A. Power Supply: Single-point external power connection with a unit-mounted non-fused disconnect switch. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000A at 480V.
- B. Disconnect Switch: Provide separate unit mounted disconnect switch complying with Section 230511.
- C. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch length of liquid-tight or flexible metallic conduit.
- D. Factory installed and wired, and functionally tested at factory before shipment.
- E. Variable Frequency Controllers: Variable frequency drives shall be mounted within dedicated pre-manufactured casing compartment. They shall not be installed outdoors without supplemental cooling. Comply with the requirements of Section 230514.

2.11. ROOF CURBS

- A. Description: Factory-fabricated, solid bottom acoustical, welded-seam self-flashing roof curb to match fan and roof-slope, constructed of galvanized sheet metal with 1 1/2-inch pressure-treated wood nailer, water-tight gasket, 1 1/2-inches of rigid fiberglass insulation, damper tray, and finished with primer and powder baked white enamel.
1. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match exhaust fan, used to anchor unit to the curb, and designed for loads at project site. Comply with requirements in Section 230548.
 2. Curb Height: 16-inches with a minimum of 12-inches above the finished roof surface.

2.12. CONTROLS

- A. Packaged Controls: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power. Control status display shall be factory mounted to the unit. Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions. Control equipment and control valves as specified in Section 230900.
1. Standalone control sequences shall include:

- a. Single-zone, variable volume air flow.
 - b. Discharge temperature, variable volume air flow.
 - c. Low ambient operation down to 0 deg F.
 - d. Enthalpy economizer.
 - e. Dry bulb economizer.
 - f. Modulating relief air flow.
 - g. Cycled constant relief air flow.
 - h. Barometric relief damper modulation.
 - i. Ventilation demand based on carbon dioxide levels.
 - j. Ventilation override mode (for smoke purge, pressurization and exhaust modes).
 - k. Refrigerant coil defrost mode.
 - l. Condensate drain pan overflow switch safety.
- B. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display packaged rooftop status and alarms.
- 1. BACnet per ASHRAE 135 communication interface with the BAS shall enable the BAS operator to remotely control and monitor the packaged rooftop units from an operator workstation. All control features and monitoring points displayed locally at packaged rooftop unit control panels shall be available through the BAS.
- C. Control Dampers: Refer to Section 233300.
- D. Damper Operators: Refer to Section 250100.
- E. Smoke Detector: Installed in the return air stream with a field connection to the building fire alarm system.

2.13. SOURCE QUALITY CONTROL

- A. Fan Sound-Power Level Ratings: Comply with AMCA 300 and 301. Fans shall bear AMCA-certified sound ratings seal.
- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210.

- C. Refrigerant Coils: Factory tested to 450 psig according to AHRI 410 and ASHRAE 33.

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 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. Equipment Mounting:
 - 1. Install units at grade on cast-in-place concrete equipment bases.
 - 2. Install units on roofs on structural steel supports or roof curbs as indicated.
 - 3. Comply with requirements for vibration isolation and wind and seismic control devices specified in Section 230548.
- B. Arrange installation of units to provide access space around units for service and maintenance.
- C. 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.
- D. Install filter-gage, static-pressure taps upstream and downstream of filters. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3. CONNECTIONS

- A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Install piping adjacent to units to allow service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans and extend to nearest drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Connect duct to units with flexible connections. Comply with requirements in Section 233300.

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.
- B. Packaged rooftop unit or components will be considered defective if unit or components do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5. STARTUP SERVICE

- A. Perform startup service per manufacturer's recommendations.
- B. Test all components and controls to verify they operate as intended.

3.6. ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 for air system testing, adjusting, and balancing.

3.7. CLEANING

- A. After completing system installation and testing, adjusting, and balancing packaged rooftop unit and air-distribution systems and after completing startup service, clean 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 packaged rooftop units.

END OF SECTION 236213

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SECTION 237433**DEDICATED OUTDOOR-AIR UNITS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes factory-packaged units capable of supplying up to 100 percent outdoor air and providing cooling and heating.

1.2. ACTION SUBMITTALS

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

1.3. 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. Filters: Two set(s) of spare filters for each unit.
 - 2. Fan Belts: Two set(s) of spare belts for each unit.

1.4. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged rooftop units to include in emergency, operation, and maintenance manuals.

1.5. COORDINATION

- A. Package Rooftop Unit manufacturer is responsible for coordination of package controls with building control system contractor.
- B. Coordinate sizes, weights (operational and shipping) and locations of supports and opening with the actual equipment provided, including:
 - 1. Concrete bases
 - 2. Structural steel support members
 - 3. Roof curbs

4. Roof/floor openings

1.6. WARRANTY

- A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.
 1. Compressors: Five years from date of Substantial Completion.
 2. Heat Exchangers: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following for air-cooled dedicated outdoor air without energy recovery:
 1. Aeon (RN series)
 2. Carrier (62D series)
 3. Daikin/McQuay (Maverick II series)
 4. Desert Aire (QS series)
 5. Munters (DryCool ERV series)
 6. Trane Company (OA series)

2.2. CABINET

- A. Casing Fabrication: Factory-fabricated and constructed wall, roof and floor double-wall galvanized steel casing panels with 2-inch (R-13) closed-cell injected-foam or board insulation within formed galvanized steel channel framing. No through-metal casing thermal breaks. All joints shall be water-resistant sealed. Casing shall meet ASHRAE 111, low leakage Class 6 with less than 1.0% leakage at 8.0-inches w.g. pressure.
 1. Casing Finish: Factory-applied prime-coat and thermosetting top-coat enamel rated for a minimum of 500 hours consecutive salt-spray test per ASTM B117.
 2. Casing Panel Deflection: Less than 0.005-inches at 8.0-inches w.g. pressure.
- B. Base Rails: Galvanized or stainless steel rails, to match the exterior casing material, for mounting on roof curb or pad as indicated.
- C. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

- D. Condensate Drain Pans: Factory-fabricated, stainless steel, water-tight sealed, minimum 2-inches deep drain pans sloped in two directions to collect condensate from cooling coils (including coil piping connections, coil headers and return bends) and direct water toward drain connection. Pan shall extend downstream of coil face to comply with ASHRAE 62.1. Drain connection shall be on the bottom side and at the lowest point on the pan. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- E. Roof Curbs: Full-perimeter solid bottom acoustical curb of sheet metal, minimum 16 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing. Comply with requirements in "The NRCA Roofing Manual."

2.3. SUPPLY AND RELIEF FANS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Shafts shall be designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment. Fan wheel, motor, and drives shall be mounted to fan casing with spring isolators. Fans shall be variable speed.
- B. Fan Housings:
 - 1. Centrifugal Fan Housings: Formed and reinforced steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell. Attach housing to fan-section casing with metal-edged flexible duct connector complying with Section 233300.
 - 2. Plenum Fan Housings: Direct-drive centrifugal type, steel frame and panel, fabricated without fan scroll and volute housing.
- C. Fan Wheels:
 - 1. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
 - 2. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
 - 3. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- D. Fan Shaft Bearings:

1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings, L50 rated for 200,000 hours with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.
- E. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 2. Motor Pulleys: Adjustable pitch for use with 5 hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 3. Belts: Oil resistant, non-sparking, and non-static V-belts; in matched sets for multiple-belt drives.
- F. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
- G. Motors: Comply with requirements of Section 230513.
 1. Shaft Grounding Rings (SGR): Pump motors 20 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.
- H. Variable Frequency Controllers: Refer to Section 230514.
 1. Mount unit-mounted variable frequency drives on exterior of unit.
- I. Motor Starters and Disconnects: Refer to Section 230511.
 1. Mount unit-mounted motor starters and disconnect switches on exterior of unit.

2.4. HEATING AND COOLING COILS

- A. Heating and Cooling Coils: Provide coil types in positions indicated. Comply with requirements of Section 238216. Coils shall comply with ARI 410.
 1. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 2. Coils shall not act as structural component of unit.
 3. Coating: Phenolic epoxy corrosion-protection coating after assembly.

2.5. REFRIGERATION SYSTEM

- A. Compressors: Scroll compressors with integral vibration isolators, internal overcurrent and over-temperature protection and internal pressure relief.
- B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.
- C. Refrigerant: R-134a, R-407C or R-410a.
- D. Capacity Control: Variable speed compressor for capacity control with continuous dehumidification on multiple compressors.
- E. Refrigerant condenser and reheat condenser coils shall be copper tube with mechanically bonded aluminum or copper fins. Coils shall be leak tested underwater with air and comply with ASHRAE 33 and AHRI 410.
- F. Provide with condenser coil hail guards.
- G. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- H. Air-Cooled Condensers:
 - 1. Condenser Fan Assembly: Direct-drive, variable speed propeller type with statically and dynamically balanced fan blades. Fan motors shall comply with requirements of Section 230513. Fan safety guards shall be steel with corrosion-resistant coating.
 - 2. Safety Controls: Compressor motor and condenser coil fan motor shall have low ambient lockout. Compressor motor shall have overcurrent protection.

2.6. INDIRECT-FIRED GAS HEATING

- A. Heat Exchanger Assembly: Factory built assembly with stainless steel heat exchanger, electronically controlled electric spark ignition with flame sensor, stainless steel drain pan, and electronic modulating gas control valve. The assembly shall comply with NFPA 54 and bear the AGA approval label.
 - 1. Fuel: Natural or propane gas.
 - 2. Thermal Efficiency: Minimum 80 percent.
 - 3. Burner Control: 9:1 modulation of total firing rate.
- B. Venting: Power vent with integral, motorized centrifugal fan interlocked with gas valve.
- C. Gas Train: Single-body, regulated, redundant, 24-Vac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

- D. Gas Pressure Regulator: Factory or field installed, sized by the manufacturer in coordination with the delivery pressure and the required connection pressure, and tagged and shipped with the unit.

2.7. FILTERS

- A. Filter Holding Frames: Provide filter holding frames arranged for flat or angled orientation, with access doors on both sides of unit. Filters shall be removable from either side.
- B. Filters: Filter sections shall be designed for the indicated filter types and orientations. Where not indicated, provide housings and frames for angled 2-inch deep filters. Refer to Section 234100.

2.8. ELECTRICAL POWER CONNECTIONS

- A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit. Wiring shall be numbered and color-coded to match wiring diagrams. Field power interface shall be NEMA 1, heavy-duty, non-fused disconnect switch.
- B. Enclosure: NEMA 250, Type 3R, mounted in unit with hinged access door in unit cabinet having a lock and key.

2.9. CONTROLS

- A. Packaged Controls: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power. Control status display shall be factory mounted to the unit. Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions. Control equipment and control valves as specified in Section 230900.
- B. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display DOAS status and alarms.
 - 1. BACnet per ASHRAE 135 communication interface with the BAS shall enable the BAS operator to remotely control and monitor the DOAS from an operator workstation. All control features and monitoring points displayed locally at DOAS control panel shall be available through the BAS.
- C. Control Dampers: Refer to Section 233300.
- D. Damper Operators: Refer to Section 230900.
- E. Smoke Detector: Installed in the return air stream with a field connection to the building fire alarm system.

PART 3 - EXECUTION

3.1. EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.
- B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."
 - 1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
 - 2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations.
 - 3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.
- C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."
- D. Equipment Mounting:
 - 1. Install air units on cast-in-place concrete equipment bases.
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.
- E. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- F. Comply with requirements for gas-fired furnace installation in NFPA 54.

- G. Install separate devices furnished by manufacturer and not factory installed.
- H. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- I. Install drain pipes from unit drain pans to roof drain unless otherwise indicated on the drawings.
 - 1. Drain Piping: Refer to Section 232113 for piping materials. Pipe size shall match condensate drain pan connection.

3.3. CONNECTIONS

- A. Where installing piping and ductwork adjacent to units, allow space for service and maintenance.
- B. Duct Connections: Comply with Section 233113 and 233300. Connect ducts to units with flexible duct connectors.
- C. Electrical Connections: Comply with Section 230511, 230513 and 230514 and Division 26. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4. 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. Inspect units for visible damage to furnace combustion chamber.
 - 3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - 4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

- a. High-limit heat exchanger.
 - b. Alarms.
5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:
 - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
 - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
 - c. Condenser coil entering-air dry-bulb temperature.
 - d. Condenser coil leaving-air dry-bulb temperature.
7. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.
18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.

21. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air flow.
 - c. Outdoor-air flow.
- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.
- D. Prepare written report of the results of startup services.

3.5. ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. 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 2 visits to project during other-than-normal occupancy hours for this purpose.

3.6. DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 237433

SECTION 238116**DUCTLESS MINI-SPLIT SYSTEMS****PART 1 - GENERAL****1.1. SUMMARY**

- A. Section includes ductless mini-split system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1.3. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For ductless mini-split system units to include in emergency, operation, and maintenance manuals.

1.4. QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: UL listed and labeled and complying with NFPA 70 and Division 26.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15.
 - 2. Comply with applicable requirements in ASHRAE 62.1.
- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.5. COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6. WARRANTY

- A. Warranty Period: Manufacturer's complete parts, labor and refrigerant warranty for 2-years and compressor warranty for 5-years from the date of substantial completion.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier/Toshiba
 - 2. Daikin/McQuay
 - 3. Johnson Controls/York
 - 4. Lennox
 - 5. Mitsubishi
 - 6. Samsung
 - 7. Sanyo/Panasonic
 - 8. Trane

2.2. SINGLE-ZONE INDOOR UNITS

- A. Concealed Evaporator-Fan Components:
 - 1. Chassis: Impact resistant plastic casing with manually adjustable discharge air vent. Mounting and configuration type as indicated.
 - 2. Insulation: Faced, glass-fiber duct liner.
 - 3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with AHRI 206/110.
 - 4. Fan: Forward-curved wheel directly connected to motor.
 - 5. Fan Motor: Multi-tapped, multispeed motors with internal thermal protection and permanent lubrication that comply with Section 230513. Connect motor to chassis wiring with plug connection.
 - 6. Filters: Minimum MERV-6, permanent, removable and cleanable.

7. Condensate Drain Pan: ABS plastic or stainless steel main drain pan with minimum 1-inch NPS drain piping connection at the pan's lowest point and fabricated to comply with ASHRAE 62.1.
 - a. Integral Condensate Pump: Provide units with integral condensate pumps where gravity drainage cannot be achieved.
 - b. Safety Overflow Switch: Electronic water sensor with manual reset switch that senses high water level and sends unit disable signal to prevent further condensate production. Drain line installed devices are not acceptable.

2.3. SINGLE-ZONE OUTDOOR UNITS

- A. Air-Cooled, Compressor-Condenser Components:
 1. Casing: Impact resistant plastic or steel with baked enamel finish with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing. Provide condenser coil with hail guards.
 2. Compressor: Hermetically-sealed inverter –duty scroll compressor with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 3. Refrigerant Charge: R-134A, R-407C or R-410A as indicated.
 4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with AHRI 206/110.
 5. Fan: Aluminum-propeller type, directly connected to motor.
 6. Motor: Permanently lubricated, with integral thermal-overload protection.
 7. Low Ambient Kit: Permits operation down to 0 deg F.
 8. Mounting Base: Polyethylene.

2.4. ACCESSORIES

- A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
 1. Remote control devices are not an acceptable alternative.
- B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- C. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1. INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548.
- E. Install and connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2. CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3. FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

3.4. STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5. DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238116

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SECTION 25 01 00**CONTROLS AND INSTRUMENTATION****PART 1 - GENERAL****1.1. SUMMARY**

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
 - 1. All Division 23 specification requirements apply to Division 25 work.

1.2. ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, installation guides, and startup instructions for each type of product indicated.
 - 1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 - 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings:
 - 1. DDC System: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 - b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 - c. Wiring Diagrams: Power, signal, and control wiring.

- d. Details of control panel faces, including controls, instruments, and labeling.
 - e. Written description of sequence of operation.
 - f. Schedule of dampers including size, leakage, and flow characteristics.
 - g. Schedule of valves including flow characteristics, pressure differentials, and flow coefficients (Cv).
 - h. DDC System Hardware:
 - 1) Wiring diagrams for control units with termination numbers.
 - 2) Schematic diagrams and floor plans for field sensors and control hardware.
 - 3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
 - i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 - j. Controlled Systems:
 - 1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - 2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - 3) Written description of sequence of operation including schematic diagram.
 - 4) Points list.
 - k. Samples for Verification: For each color required, of each type of thermostat or sensor cover.
2. Display Graphics: Provide a sample of proposed display graphics for each screen page and a flowchart diagram showing how each screen will be linked to the other. Where there are multiple systems or equipment that are repetitive, it is acceptable to provide one and note it applies to others. For example, one terminal unit screen graphic may be submitted as an example to represent all the terminal units of that type for the project.
- a. Owner's Graphic Standards: The owner's graphic standards shall be followed.

1.3. INFORMATIONAL SUBMITTALS

- A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
- B. Qualification Data: For installer.
- C. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

1.4. CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals, including the following:
 - 1. Maintenance instructions and lists of spare parts for each type of control device.
 - 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 - 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 - 5. Calibration records and list of set points.
 - 6. Verification of 100 percent of all control and monitoring points and all control sequences prior to Engineer witnessing.
- B. Software and Firmware Operational Documentation: Include the following:
 - 1. Software operating and upgrade manuals for all software required to program and maintain the system.
 - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
 - 5. Software license required by and installed for DDC workstations and control systems.
- C. Software Back-Up Electronic Files

1.5. MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, humidistat and positioning relay.

1.6. QUALITY ASSURANCE

- A. The building automation system (BAS) shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be factory authorized in good standing with the manufacturer and located within 100 miles of the project site. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request. A full-time on-site experienced project manager for this work shall be responsible for the direct supervision of the installation and start-up of the system.
 - 1. Upon request, installer shall present records of successful completion of factory training courses.
 - 2. Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.
 - 3. Upon request, the installer shall provide a list of 10 projects of similar scope and complexity within the past 5 years with the project owner's contact information.
- B. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this project.
 - 1. Tridium Niagara Certification: The system programmer(s) shall have successfully completed the Tridium certification training courses related to the applicable versions of Niagara. Current software version is 3.8.111. Coordinate with existing owners system.
- C. Electrical Components, Devices, and Accessories: UL listed and labeled complying with the requirements of NFPA 70, Section 230511 and Division 26.
- D. Comply with UL 916 for Energy Management Systems.
- E. Control panels, new and modified, shall comply with UL 508A. Field-built or modified panels shall be inspected, listed and labeled in the field or replaced with an equivalent shop built panel that is listed and labeled.
- F. Local and Terminal Control Units shall be BACnet Testing Lab (BTL) listed.
- G. Comply with ASHRAE 135 for DDC system components.

1.7. DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software compatible with version 3.8.111 at project completion. If the Owner has an established energy management system serving buildings outside the scope of this project, ensure the software is compatible with the existing system without needing to update it.

1.8. COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Engineer prior to installation.
- B. Coordinate equipment with the fire alarm system to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate sources of 120V power with the Electrical Contractor and Owner for control units, operator workstation and other devices. Extend power from sources as needed.
- D. Coordinate location of data ports with the Electrical Contractor and Owner.

1.9. SEQUENCE OF OPERATION

- A. Sequences of Operation are located on the control drawings. Submit standard sequences for incidental items not shown for Engineer approval.

1.10. WARRANTY

- A. Building Automation System: Parts and labor for 1 year from the date of substantial completion. The Owner reserves the right to make changes to the BAS during the warranty period and such changes do not constitute a waiver of the warranty.
 - 1. The Owner shall allow remote access to the BAS for diagnostic testing and monitoring during the warranty period.
 - 2. Upon request, a technician shall be on site to resolve the Owner reported issue within 24 hours of it being reported if it has not been resolved remotely to the Owner's satisfaction.
- B. Electronic Actuators: Parts and labor for 5 years from the date of substantial completion.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Distech Controls (BACnet Series).
 - 2. American Auto-Matrix/Cylon Energy (Integra Series) (Preferred Brand Alt)
 - 3. Johnson Controls (Facility Explorer Series)
- B. Products by the DDC system manufacturer shall include user interface, controller software, application programming language and equipment and application controllers. Sensors, actuators, valves, dampers and other components may be manufactured by others as indicated.
- C. Description: DDC system with BACnet system level protocol, having all points exposed to BACnet/IP, and Tridium Niagara 4 or AX integration software framework. The control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics. The control system shall be complete and fully operable.
 - 1. Tridium Niagara Licenses: All Niagara based systems shall have "open" licenses. The system shall not prevent another vendor from accessing and modifying the software with the proper admin login. Proprietary software shall not be required for future vendors to integrate with this system. No proprietary JAR (Java ARchive) files or other drivers shall be used on the Vicon JACE hardware. If any hardware or software must be modified, repaired, or replaced in the future, any qualified vendor shall be able to do so without the support of this system's vendor.

2.2. OPEN ARCHITECTURE

- A. DDC system shall provide an open, interoperable and integrated architecture with a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate BACnet/IP, BACnet MS/TP, LonWorks, Modbus IP, Modbus RTU, Modbus TCP, Niagara 4, AX and R2 and proprietary legacy communication protocols in a single interoperable system. The system shall be accessible by web browsers with secured access.
- B. BACnet Compliance: Comply with ASHRAE Standard 135. For each BACnet device, submit Protocol Implementation Conformance Statement (PICS) document showing the device's minimum compliance of Level 3 and able to support read/write functions.

1. Modbus: For each Modbus device, submit Registry Map of available data points.
- C. BACnet Device Connections: Physical connection to BACnet devices shall be Ethernet (BACnet/IP) and/or RS-485 (BACnet MS/TP) cables.
- D. Peer-to-Peer Controllers: Controllers shall be peer-to-peer communicating devices. Controllers requiring "polling" by a host to pass data is not acceptable.
- E. Control System Server: Structural Query Language (SQL) using Open Database Connectivity (ODBC) compliant server database stored on a server. Systems requiring a proprietary database and/or user interface programs are not acceptable.

2.3. SYSTEM PERFORMANCE

- A. Description: The system shall comply with the following minimum performance requirements:
 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 6. Program Execution Frequency: Run capability of applications as often as 5 seconds, but selected consistent with mechanical process under control.
 7. Performance: Programmable controllers shall execute DDC PID control loops and scan and update process values and outputs at least once per second.

2.4. NETWORKS

- A. Virtual Local Area Network (VLAN): The minimum 100 MB/second Ethernet VLAN shall connect multiple Vicon Java Application Control Engines (JACE's). The VLAN shall support XML internet protocol, Hypertext Transfer Protocol (HTTP), Simple Object Access Protocol (SOAP), Java, BACnet and LonWorks.
- B. Local Area Network (LAN): The minimum 100 MB/second Ethernet LAN shall comply with IEEE Standard 802.3 and use 100 Base-TX, UTP-8 wire, Category 5 (Cat 5) cabling.

- C. Remote Access: The VLAN shall be accessible without proprietary software by commonly available web browsers (i.e. Microsoft Internet Explorer, Google Chrome, Mozilla Firefox and Apple Safari) with tiered username and password security access.
 - 1. Internet Access: The Owner shall provide high-speed internet connection for access to the VLAN. The Owner shall provide temporary secured access, for the duration of the project through the one-year walk-through, to the VLAN users.
 - 2. Graphics: The web browser view of the graphics shall be the same as provided by the Operator Interface Graphic Software when accessed directly on the Owner's network. The web browser graphics shall support URL hypertext links for other locations on the internet and intranet.

2.5. DDC EQUIPMENT

- A. BAS Server: Connect to existing county web supervisor server. Coordinate with the owner for compatibility requirements.

2.6. DDC SOFTWARE

- A. General Requirements:
 - 1. Alarm processing, messages, and reactions.
 - 2. Trend logs retrievable in spreadsheets and database programs.
 - 3. Alarm and event processing.
 - 4. Object and property status and control.
 - 5. Automatic restart of field equipment on restoration of power.
 - 6. Data collection, reports, and logs. Include standard reports for the following:
 - a. Current values of all objects.
 - b. Current alarm summary.
 - c. Disabled objects.
 - d. Alarm lockout objects.
 - e. Logs.
 - 7. Custom report development.
 - 8. Utility and weather reports.

9. Workstation application editors for controllers and schedules.
 10. Maintenance management.
- B. Custom Application Software:
1. English language oriented.
 2. Full-screen character editor/programming environment.
 3. Allow development of independently executing program modules with debugging/simulation capability.
 4. Support conditional statements.
 5. Support floating-point arithmetic with mathematic functions.
 6. Contains predefined time variables.
- C. Archiving: Automatically store data base back-up and trend data at one operator workstation and the server without operator action. Operator shall be able to manually download entire controller databases or parts thereof.

2.7. OPERATOR INTERFACE GRAPHIC SOFTWARE

- A. General:
1. Graphic software shall provide user-friendly and intuitive operation of the systems with minimal training and experience at each level of interface, including operator workstations, diagnostic terminal units, and mobile applications. It shall allow multi-tasking for third-party software and alarm graphics to display when in other software windows.
 2. Dynamic Data Displays: Automatically update point values at a minimum frequency of every 10 seconds or less. Data point displays shall be color-coded and indicate normal, abnormal, alarm, signal loss and override conditions.
 3. Override Function: Graphic software shall allow an override for each digital data point value and for each change in analog status. The override value shall reside in the equipment controller not just at the OWS.
 - a. Password Protection: Provide password protection for each level of importance as determined with the Owner.
 - b. Override Tracking: Each override shall be tagged with the associated operator's identification number, name or initials.
- B. Floor Plan Graphics:

1. Provide floor plan graphics for all areas of the building(s) served by the BAS. Create floor plans with an appropriate level of detail based on the construction documents. Copying the construction document files is not acceptable as they usually contain too much detail to be legible on a single screen shot. Submit the proposed graphics with the Owner / Engineer for approval.
2. Provide links from floor plans to enlarge floor plan areas (zoom in feature). Provide links from enlarged floor plans to equipment diagrams.
3. Provide links from zone sensor locations on the floor plans to associated terminal equipment. Each temperature control zone shall be clearly indicated on the floor plans.
4. Coordinate room names and numbers with the Owner and building signage. Often the final room names and numbers differ from the construction documents.

C. Equipment / Terminal Unit Graphics:

1. Provide an equipment diagram indicating each component and sensor with a link to the written sequence of operation, maintenance notes, etc. Each diagram shall indicate all data points. Parameters shall be overridden / changed from the graphic.
2. Provide a link to associated equipment for each diagram. (For example, a terminal unit might have a link at the reheat coil to the heating water plant and the terminal box to the AHU feeding it.)
3. Provide a location for any point associated with an equipment diagram but located remotely. For example, a duct-mounted pressure sensor in the AHU diagram might be indicated to be 'Located AFC in 24x12 SA duct in Corridor 100 outside Room 101'.)
4. Terminal Unit Graphics: Typical terminal unit graphics shall include:
 - a. Minimum and maximum flow setpoints
 - b. Heating flow setpoints
 - c. Zone heating and cooling temperature, high and low humidity and carbon dioxide high limit setpoints (if applicable)
 - d. Terminal unit percent of maximum heating and cooling
 - e. Occupancy control mode and status
 - f. Alarm status.

D. Alarm Reporting:

1. Alarm Tag: Each alarm shall have a unique description tag, date and time. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store each alarm message.
 2. Alarm Prioritization: Each alarm type shall be assigned a priority level as defined by the Owner.
 3. Alarm Acknowledgment: Each alarm shall be acknowledged by a recipient with password authorization via any form of operator interface. The alarm acknowledgement information including operator, date and time shall be saved with and append the alarm tag.
 4. Alarm Summary Logs: Operators shall be able view all alarms and acknowledgements. They shall be sortable by date and time, operator, alarm type, and alarm priority.
 5. OWS interface shall monitor all alarms. Alarm notifications shall be automatically sent to Owner staff via email and text messaging based on staff and alarm prioritization. The system's ability to report alarms shall not be affected by a breakdown in communications with other control panels on the network.
 6. Alarms shall be defined by the Engineer's sequences of operation and the Owner.
- E. Trend Reporting:
1. Trend Tag: Each trend shall have a unique description tag, date and time duration. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store trend data.
 2. Trend Summary Logs: Operators shall be able view all trend data. They shall be sortable by initiation date and time, operator, trend type.
 3. Trend Data Collection: Data shall be exported to a compressed file on the server in MS Excel or MS Access format. Data shall be able to be stored without over-writing the collected data files for no less than one year.
 4. Initial trends shall be defined by the Engineer's sequences of operation. Final trends at project completion shall be determined by the Engineer and Owner once the building systems are fully operational and functioning properly.

2.8. DDC CONTROLLERS

A. BAS Controllers:

1. Provide BACnet Controllers that BACnet Testing Laboratory listed (v12 or later) as specified herein:

- a. BACnet Building Controller (B-BC)
 - b. BACnet Advanced Application Controller (B-AAC)
 - c. BACnet Application Specific Controller (B-ASC)
2. All BACnet Controllers shall use the following communication specifications and achieve performance as specified herein:
 - a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU). Any controller on the MS/TP Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Sub-controllers (aka "slave" controllers) are not acceptable.
 - b. Performance:
 - 1) Each BACnet MS/TP controller shall have a minimum of 64Kb of RAM and 384Kb of non-volatile flash memory.
 - 2) Each controller shall have a 32-bit microprocessor operating at 68 MHz and support a BACnet protocol stack in accordance with the ANSI/ASHRAE Standard 135-2008 and the BACnet Device Profile supported.
 - 3) Each BACnet controller on the BACnet MS/TP communications trunk shall provide a loading characteristic of minimum 1/8th Load.
 - 4) Manufacturers, who wish to supply Local Control Unit (LCU) and Terminal Control Unit (TCU) controllers with less than a 32-bit microprocessor and/or a MS/TP loading characteristic of greater than 1/8th Load, may do so as long as they only provide a maximum of 24 controllers on a single bus segment per NCU.
3. BACnet Controllers shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as needed. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
4. Local Control Units (LCU) and Terminal Control Units (TCU): Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications. All control sequences programmed into the LCU and TCU shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
5. BACnet Controllers shall communicate with the Network Control Unit (NCU) via a BACnet/IP connection at a baud rate of not less than 100 Mbps or via the RS485 MS/TP connection at a baud rate of not less than 76.8 kbps.

6. BACnet TCU to have a communications port for connecting a matching room temperature and/or humidity sensor and does not utilize any of the I/O points of the Controller.
 7. Provide documentation for each device, with the following information at a minimum:
 - a. BACnet Device; MAC address, name, type and instance number.
 - b. BACnet Objects; name, type and instance number.
 8. Controllers shall have an enclosure appropriate for their environment as approved by the Engineer. Comply with NEMA enclosure requirements in Section 230511.
 - a. Indoor Enclosures: Rated for operation at 32 to 122 deg F and 5 to 95% RH non-condensing.
 - b. Outdoor Enclosures: Rated for operation at 0 to 150 deg F.
- B. Local Control Units (LCU): For primary systems (such as AHU, MAU, chiller, boiler, and water systems.)
1. Local Control Units (LCU) shall be 32 bit microprocessor-based.
 - a. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.
 - b. Controller size shall be sufficient to fully meet the requirements of this specification and the sequence of operations.
 2. Each LCU shall have sufficient memory, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and manual override monitoring.
 3. Each LCU shall support monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:
 - a. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.
 - b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
 - c. Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:

- 1) Digital outputs of 24 Vdc (contact closure for motor starters up to size 4).
- 2) Analog outputs of 4-20 mA and 0-10 Vdc.
4. LCU analog or universal input shall use a 16 bit A/D converter. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.
5. LCU analog or universal output shall use a 10 bit D/A converter.
6. Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection.
 - a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
 - b. As a minimum, provide one of each type of point available on the controller.
7. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
 - 1) The operator interface shall consist of an icon-based, interactive backlit color display with navigable menus to display, edit and modify internal controller functions.
 - b. The operator interface shall use color-codes with icons and text lists to indicate values and controller statuses.
 - c. The operator interface shall, at a minimum, have the following functions:
 - 1) Points: The operator interface shall provide points list menus to view the inputs, setpoints, and output values such as hardware inputs/outputs, analog values, binary values, and multistate values.
 - a) The points list menus shall allow the operator to monitor, set, and override controller points and values.
 - b) A color-code shall be used to indicate the conditions and statuses of points displayed in the points list menus.
 - 2) Alarms: The operator interface shall provide a controller's alarms menu to view details of an alarm, to acknowledge the alarm, and to view the alarm history.
 - a) The alarm menu shall allow the operator to view the following type of alarms: active not acknowledged, active acknowledged, and inactive not acknowledged.

- b) The combination of an icon and its color state shall notify the operator of an alarm condition.
 - c) The operator shall be able to select a single point in alarm to view further details such as the alarm to/from status, current status, event date and time, alarm event threshold, and alarm event value.
 - 3) Overrides: The operator interface shall provide an overrides menu to view a list of the controller's overridden points such as hardware input, hardware output, value, constant, or variable. The menu shall allow the operator to select an overridden point and to modify or release the override on the selected point.
 - 4) PID loops: The operator interface shall provide a PID Loops menu to view, configure, and adjust the PID parameters. The interface shall also provide visual PID tuning with live system response graphing (live-trend).
 - 5) The operator interface shall allow personalization of a contact information screen with a minimum of eight (8) lines of user configurable text as well as the option to add a color graphic such as a company logo. The tool shall support, but not be limited to; image file formats such as GIF, PNG, JPG, etc.
 - 6) Favorites: The operator interface shall allow access to a list of bookmarked points.
 - 7) Weather: The operator interface shall provide a weather menu to view the current weather conditions with a weather status icon. The units shall be configured to be displayed in either metric or US units.
 - 8) Password Protected: The controller operator interface shall provide multi-level password protection, with user-defined, alphanumeric, name/password combinations. The operator interface shall return to lock mode after a user-defined log-off delay. A password icon shall indicate the lock mode state.
 - 9) Settings: The operator interface shall provide a settings menu to view and configure date and time parameters such as the current time, time zone, and daylight savings time.
- 8. LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.
 - 9. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN operator workstation or server.
 - 10. Provide an onboard network communication jack for connection to the network (RJ-45 or equivalent quick connect)

- C. Terminal Control Units (TCU): For secondary systems such as VAV, fan-powered VAV, fan coil, radiation, and reheat coils.
1. Provide Terminal Control Units (TCU) for control of each piece of terminal equipment.
 2. TCU controllers shall be powered from a 24 Vac source.
 3. Controllers shall also function normally under ambient conditions of 32 to 120 deg F and 5 to 90 percent RH (non-condensing).
 4. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
 5. Terminal Control Units (TCU) shall be 32 bit microprocessor-based.
 6. They shall be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.
 7. Each TCU shall have sufficient memory, to support its own operating system and databases, including: control processes, maintenance support applications, custom processes, and manual override monitoring.
 8. Each TCU shall support monitoring of the following types of inputs, without the addition of equipment:
 - a. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.
 - b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
 - c. Each TCU shall be capable of providing the following control outputs without the addition of equipment: digital outputs (contact closure for motor starters up to size 4) and analog outputs of 4-20 mA or 0-10 Vdc.
 9. TCU analog or universal input shall use a 16 bit A/D converter. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.
 10. TCU analog or universal output shall use a 10 bit D/A converter.
 11. Controllers shall include all point inputs and outputs necessary to perform the specific control sequences.
 - a. As a minimum, 25% of the point outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility.

- b. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators.
- 12. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted.
 - a. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable.
 - b. The controller shall receive its real-time data from the NCU controller time clock to insure LAN continuity.
 - c. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications.
 - d. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.
 - e. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings.
- 13. Provide each TCU with sufficient memory to accommodate point databases, operating programs, local alarming and local trending.
 - a. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM.
 - b. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
 - c. Operating programs shall be field selectable for specific applications.
 - d. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility.
 - e. Controllers that require factory changes of all applications are not acceptable.
- D. Variable Air Volume (VAV) Terminal Control Units (TCU):
 - 1. VAV TCU controllers shall be powered from a 24 Vac source.
 - 2. The controllers shall also function normally under ambient conditions of 32 to 122 deg F and 5 to 90 percent RH (non-condensing).
 - 3. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
 - 4. VAV TCU shall include a built-in 'flow thru' differential pressure transducer.
 - a. The controller shall convert this value to actual air flow.

- b. Single point differential pressure sensing device is not acceptable.
- c. Membrane based pressure differential transducer is not acceptable.
- d. VAV TCU differential pressure transducer shall have a measurement range of 0 to 2 inches wc and measurement accuracy of plus or minus 4 percent at 0.05 to 2 inches wc and a minimum resolution of 0.0001 inches wc, insuring primary air flow conditions shall be controlled and maintained to within plus or minus 5 percent of setpoint at the specified minimum and maximum air flow parameters.
- e. VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable.
- f. BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.
- g. VAV TCU shall include provision for air flow balancing using a local air flow balancing interface.
- h. The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.
- i. VAV TCU shall also provide an air flow balancing tool. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.
- j. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements.
- k. It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.

2.9. ANALOG CONTROLLERS

- A. Step Controllers: 6 or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.
- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

- D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
- E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
 - 1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
 - 2. Proportional band shall extend from 2 to 20 percent for 5 psig.
 - 3. Authority shall be 20 to 200 percent.
 - 4. Air-supply pressure of 18 psig input signal of 3 to 15 psig, and output signal of zero to supply pressure.
 - 5. Gages: 1 1/2-inch diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.10. ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Provide sensors as indicated in control diagrams and sequences of operation or as needed to perform the intended operations.
- C. Temperature Sensors:
 - 1. General Requirements:
 - a. Accuracy:
 - 1) Thermistor: Plus or minus 0.5 deg F at calibration point.
 - 2) RTD: Plus or minus 0.2 percent at calibration point.
 - b. Wire: Twisted, shielded-pair cable.
 - 2. Outside Air Temperature (OAT) Sensor: Thermistor or RTD compatible with BMS installed in wall-mounted weatherproof enclosure with conduit entrance and aluminum LB with PVC sun and windscreen.
 - 3. Duct-Mounted Single-Point Temperature Sensor: Thermistor or RTD compatible with BMS, sealed in 0.25-inch stainless steel probe of length

between one-third and two-thirds of the duct width in duct-mounted metal housing with conduit entrance.

- a. Single-point may be used in ducts less than 9 sqft. in cross-sectional area and in ducts greater than 9 sqft. in cross-sectional area if there is no heating coil and no cooling coil and no mixing of air flows of different temperature upstream.
 4. Duct-Mounted Averaging Element Temperature Sensor: Thermistor or RTD compatible with BMS, 36-inch averaging element.
 - a. Averaging elements shall be used where ducts are larger than 9 sqft. in cross-sectional area or where prone to stratification.
 5. Wall-Mounted Temperature Sensor: Thermistor or RTD compatible with BMS with insulated back.
 - a. Private Spaces: White plastic enclosure with set point adjustment, push button override switch, and LED display.
 - b. Public Spaces: Stainless steel plate sensor that fits in a standard 4-inch by 2-inch junction box with tamperproof screws.
 6. Wall-Mounted Microprocessor-Based Temperature Sensor: Thermistor or RTD compatible with BMS in white plastic enclosure with insulated back, LED display of space temperature and set point and push button override switch.
- D. Humidity Sensors:
1. General: 4-20 mA two wire and 0-10 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS and 24 Vac/dc power supply.
 - a. Accuracy: 2 percent over 5 to 95 percent range with linear output.
 - b. Temperature: 32 to 120 deg F.
 2. Wall-Mounted Relative Humidity Sensor: Laser-trimmed thermoset polymer-based capacitive-type sensor in white plastic enclosure with insulated back, set point adjustment, push button override switch, and LED display.
 - a. Range: 20 to 80 percent.
 3. Duct-Mounted Relative Humidity Sensor: Laser-trimmed thermoset polymer-based capacitive-type sensor with 9-inch long probe in duct-mounted metal housing with conduit entrance.
 - a. Range: 0 to 100 percent.

4. Outside Air Relative Humidity (OAH) Sensor: Laser-trimmed thermoset polymer-based capacitive-type sensor with weatherproof enclosure with conduit entrance.
 - a. Range: 0 to 100 percent.
- E. Combination Relative Humidity and Temperature Sensors: Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, provide combination relative humidity and temperature sensors. The individual sensors must each meet the specifications details herein.
- F. Pressure Sensors:
 1. Duct-Mounted Static Pressure Sensors: Non-directional sensor with 4-20mA or 0-10Vdc output proportional to pressure input range compatible with BMS system.
 - a. Range: 0 to 6-inches wg for low and medium pressure applications and higher as approved for high pressure applications.
 - b. Accuracy: 2 percent of full scale output.
 - c. Temperature: 32 to 140 deg F.
 2. Room Pressure Sensors: Non-directional sensor with 4-20mA or 0-10Vdc output proportional to pressure input range compatible with BMS system.
 - a. Range: Minus 0.2-inches to positive 0.2-inches wg.
 - b. Accuracy: 2 percent of full scale output.
 - c. Temperature: 32 to 140 deg F.
 3. Air Filter / Coil Differential Pressure Sensors: Non-directional sensor with 4-20mA or 0-10Vdc output proportional to pressure input range compatible with BMS system. Sensors shall have a local display.
 - a. Range: 0 to 2-inches wg.
 - b. Accuracy: 2 percent of full scale output.
 - c. Temperature: 32 to 140 deg F.
 4. Air Differential Pressure Switch: Snap-acting single-pole double-throw (SPDT) in NEMA 13 housing with automatic reset and set-point adjustment knob.
 - a. Range: 0 to 0.25-inches wg for building and duct pressurization applications; 0 to 1.50-inches wg for filter alarms; and 0 to 8-inches wg for high static alarms.
 - b. Accuracy: 2 percent of full scale output.

- c. Temperature: 0 to 140 deg F.
- 5. Air Flow Sensors: Hot wire anemometer type sensor with 4-20 mA or 0-10Vdc output proportional to air flow speed and 24 Vac/dc power supply. Probe and transducer housing shall be constructed of durable PVC.
 - a. Range: 0 to 6-inches wg.
 - b. Accuracy: 5 percent of measured value.
 - c. Temperature: 0 to 140 deg F.
- G. Electronic Sensors:
 - 1. Current Relays / Switches: Current relays shall be rated for their associated load; have input and output isolation via current transformer; and be self-powered with no insertion loss. The output relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status. Relay shall be in a dustproof housing.
 - a. Accuracy: 2 percent of full scale.
 - b. Temperature: 0 to 140 deg F.
 - 2. Current Sensor: Sensor with 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw and rated for 50/60 Hz operation.
 - a. Accuracy: 1 percent
 - b. Temperature: Minus 20 to positive 120 deg F.

2.11. STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
- B. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- C. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- D. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

- E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- F. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.12. DETECTION EQUIPMENT

- A. Carbon Dioxide (CO₂) Sensors: Microprocessor based sensor with 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to 0 to 2000 ppm of carbon dioxide concentration and 24 Vac/dc power supply.
 - 1. Accuracy: Plus or minus 50 ppm.
 - 2. Temperature: 32 to 120 deg F.
 - 3. Calibration: No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing the Automatic Calibration Logic Program (ACLP).
- B. Occupancy Override Switch: Low-voltage wall switch in a standard single-switch back box with momentary switch, green LED "on" indicator light, with white plastic faceplate. Hubbell (LVSM series) or equal.
- C. Occupancy Sensor: Dual-technology passive infrared (PIR) and ultrasonic occupancy sensor with adjustable time delay of 5 to 45 minutes, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush wall or ceiling mounting in standard metal outlet box. Provide sensor with LED light to indicate when motion is being detected during test and normal operation. Provide sensor with auxiliary dry contacts. Power supply to the sensor shall be 24Vdc, located within the outlet box and be plenum-rated.
 - 1. Subject to compliance with requirements, provide products by the following:
 - a. Ceiling-Mounted Sensors: Cooper Lighting/Eaton (MicroSet Series), Hubbell (OMNI Series), Leviton (OSC Series), Lutron (LOS C Series) or Watt Stopper (LMDC Series).

2.13. THERMOSTATS

- A. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
 - 1. Label switches "FAN ON-OFF", "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF" as applicable.
 - 2. Mount on single electric switch box.
- B. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.
 2. Preferential rate control to minimize overshoot and deviation from set point.
 3. Set up for four separate temperatures per day.
 4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
 5. Short-cycle protection.
 6. Programming based on weekday, Saturday, and Sunday.
 7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
 8. Battery replacement without program loss.
 9. Thermostat display features include the following: time of day, actual room temperature, programmed temperature, programmed time, duration of timed override, day of week, and system mode indications include "heating," "off," "fan auto," and "fan on."
 10. Combination Thermostat, Humidistat, Carbon Dioxide, and/or Occupancy Sensor: Where there is a requirement for a thermostat with humidistat, carbon dioxide, and/or occupancy sensing functions at the same location, provide combination unit. The individual sensors must each meet the specifications details herein.
- C. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-free, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
- D. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 2. Selector Switch: Integral, manual on-off-auto.
- E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
1. Bulbs in air ducts with flanges and shields.
 2. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.

3. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 4. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 5. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- F. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
- G. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
1. Bulb Length: Minimum 20 feet.
 2. Quantity: One thermostat for every 20 sqft. of coil surface.
- H. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.
1. Bulb Length: Minimum 20 feet.
 2. Quantity: One thermostat for every 20 sqft. of coil surface.
- I. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig and cast housing with position indicator and adjusting knob.

2.14. ACTUATORS

- A. Manufacturers: All valve actuators shall be supplied from a single manufacturer. All damper actuators shall be supplied from a single manufacturer. Provide actuators manufactured by one of the following:
1. Belimo
 2. Honeywell
 3. Johnson Controls
 4. Schneider Electric (TAC Dura-Drive)

5. Siemens
- B. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
1. Comply with requirements in Section 230513.
 2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 3. Non-Spring-Return Motors for Valves Larger Than 2 1/2-inch NPS: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 4. Spring-Return Motors for Valves Larger Than 2 1/2-inch NPS: Size for running and breakaway torque of 150 in. x lbf.
 5. Non-Spring-Return Motors for Dampers Larger Than 25 sqft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 6. Spring-Return Motors for Dampers Larger Than 25 sqft.: Size for running and breakaway torque of 150 in. x lbf.
- C. Electronic Actuators: Direct-coupled type with stroke indicator and designed for minimum 60,000 full-stroke cycles at rated torque.
1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sqft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sqft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sqft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sqft. of damper.
 - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
 3. Coupling: V-bolt and V-shaped, toothed cradle.
 4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.

6. Power Requirements:
 - a. Two-Position Spring Return: 24Vac.
 - b. Modulating: Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
8. Temperature Rating:
 - a. Standard Dampers and Valves: Minus 22 to plus 122 deg F.
 - b. Smoke Dampers: Minus 22 to plus 250 deg F.
9. Run Time:
 - a. Normal: 120 seconds open or closed.
 - b. Fast-Acting: 12 seconds open, 5 seconds closed unless otherwise noted.
 - 1) Smoke Control System Components
 - 2) Emergency System Components
 - 3) Fuel Shut-Off Valves
10. Housing: Minimum NEMA Type 2, mounted in any orientation, for indoor locations and NEMA Type 3R, mounted in any orientation, for outdoor locations.

2.15. ELECTRIC CONTROL COMPONENTS

- A. Limit Switches: Single-pole double-throw (SPDT) or double-pole double-throw (DPDT) type, UL-listed with adjustable trim arm.
- B. Control Relays: Rated for application, UL-listed, and mounted in NEMA 1 enclosure for indoor locations and NEMA 4 for outdoor with pilot light indicator of power-to-coil.
 1. Time Delay Relays: Capable of on or off delay functions with adjustable timing periods, cycle timing light with solid state, plug-in type coils with transient suppression devices.
- C. Control Transformers: Rated for application, UL-listed, and mounted in NEMA 1 enclosure for indoor locations and NEMA 4 for outdoor with replaceable fuses on the primary and secondary side. Transformers shall be sized so that connected load does not exceed 75 percent of rating.
- D. Power Contactors: NEMA ICS 2 AC general purpose magnetic contactor mounted in NEMA 1 enclosure for indoor locations and NEMA 4 for outdoor.

2.16. CONTROL DAMPERS

- A. Dampers: Refer to Section 233300 for control damper requirements.

2.17. CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring shall comply with Section 230511 and Division 26.

2.18. ELECTRICAL CONNECTIONS

- A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.
- B. Comply with the requirements of Section 230511 and Division 26.

PART 3 - EXECUTION**3.1. EXAMINATION**

- A. Verify that power supply is available to control units and operator workstation.
- B. Verify that duct, pipe, and equipment-mounted devices are installed before proceeding with installation.

3.2. INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor per ADA requirements. The location(s) to be selected by the Engineer. No sensor shall be mounted until the Engineer/Architect gives specific location instructions.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
 - 2. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
 - 3. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

4. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 foot of sensing element for each 1 square-foot of coil area.
 5. Install outdoor air temperature sensors on north wall at designated location with sun shield.
- D. Install aspirating guards on thermostats in the following locations:
1. Building entrances.
 2. Public areas.
 3. Where indicated.
- E. Differential Air Static Pressure.
1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
 2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
 3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
 4. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
 5. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.
- F. Damper Actuators, Electric or Electronic
1. Install automatic dampers according to Section 233300.
 2. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.
 3. Link actuators according to manufacturer's recommendations.
 4. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
 5. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately the 5° open position, manually close the damper, and then tighten linkage.

6. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 7. Provide necessary mounting hardware and linkages for actuator installation.
 8. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Section 230553.
- H. Install refrigerant instrument wells, valves, and other accessories according to Section 232300.
- I. Install duct volume-control dampers according to Sections 233113.
- J. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
- K. Install flow switches with correct paddle for pipe diameter. Adjust flow switch according to manufacturer's instructions.
- L. Provide current sensing relays at the MCC starters.
- M. Install electronic and fiber-optic cables according to Division 26. Provide sufficient slack and flexible connections to allow for duct, piping and equipment vibration isolation.
- N. Install carbon monoxide (CO) monitoring systems as indicated.
1. Provide CO monitoring systems for the enclosed levels of the parking garage. Provide complete coverage of the enclosed levels of the parking garage and provide systems for each level. A CO monitoring system shall not cover an area on more than one level and the failure of any component shall not affect more than one level.
 2. Locate sensing points on walls and columns at 5 to 6 feet above floor level. Locate one sensing point per 7500 square-feet. Do not locate sensing points closer than 6ft to traffic lanes.

3.3. ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor or Owner.

- B. Install raceways, boxes, and cabinets according to Section 230511 and Division 26.
- C. Install building wire and cable according to Section 230511 and Division 26.
- D. Install signal and communication cable according to Section 230511 and Division 26. Comply with manufacturer's installation guidelines.
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4. FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 6. Test each system for compliance with sequence of operation.
 7. Test software and hardware interlocks.
- B. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check instrument tubing for proper fittings, slope, material, and support.
 5. Check installation of air supply for each instrument.
 6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 8. Check temperature instruments and material and length of sensing elements.
 9. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
 - e. Verify all control valves have been installed at the correct locations.
 - f. Verify all control dampers have been installed at the correct locations.
- C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5. ADJUSTING

- A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milli-ampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.
 11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to six visits to Project during other than normal occupancy hours for this purpose.

3.6. DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

3.7. SOFTWARE BACK-UPS

- A. Upon completion including final adjustments, provide two (2) complete back-up electronic copies of software files for each operator workstation, server, diagnostic terminal unit and equipment controller. The software files shall include all data and software files needed to completely reset or re-install the software for the entire project including a text file with a written description of the reinstall process. Each copy shall be saved to an external hard drive.
1. External Hard Drive: 2 TB, 3.0/2.0 USB, portable hard-drive manufactured by Seagate, Toshiba or Western Digital.

3.8. SOFTWARE UPDATES

- A. At 12-months from the date of Substantial Completion, update the BAS software to the most recent release. The update(s) shall be scheduled with the Owner and performed under their direct supervision. Verify proper operation after the installation and correct any problems created by the installation process.
1. Software update shall include all labor, licensing and associated fees.

END OF SECTION 250100

SECTION 260100**BASIC ELECTRICAL REQUIREMENTS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All sections of Division 26 are interrelated. Where materials are required to complete work associated with equipment in a specific section, but the materials are not specified within that specific section, the requirements for those materials shall be as specified elsewhere in Division 26.

1.2 SUMMARY

- A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:
 - 1. Submittals.
 - 2. Coordination drawings.
 - 3. Record documents.
 - 4. Maintenance manuals.
 - 5. Rough-ins.
 - 6. Electrical installations.
 - 7. Cutting and patching.
 - 8. Inspections
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 26 Section "Basic Electrical Materials and Methods," for materials and methods common to the remainder of Division 26.

1.3 SUBMITTALS

- A. General: Follow the procedures specified in Division 01 Section "Submittal Procedures".
- B. Specific Requirements to Electrical Product Data and Shop Drawing Submittals:

1. Submit newly prepared information, drawn to scale where applicable. Do not reproduce Contract Documents or use Contract Document images in the preparation of submittals.
 2. Any deviations from Contract Documents shall be clearly noted and highlighted, encircled, or otherwise visually identified.
 3. Product Data and Shop Drawings are separate items and shall be submitted with separate submittal numbers. Where both Product Data and Shop Drawings are required by the same specification section (i.e. Fire alarm) both items shall be submitted for review at the same time. Product Data and Shop Drawings will be reviewed separately by Engineer, but Engineer reserves the right to withhold review until both items have been received.
 4. Submittal Documents Quality: Facsimile documents are prohibited. Submittals containing sheets copied from facsimile documents will be automatically Rejected and returned to Contractor without review. Also submittals containing poor quality copies will be automatically Rejected and returned to Contractor without review.
 5. Submittal Document Binding: Use report covers with 3-hole, dual-prong tang fasteners or slide fasteners. Velo- and comb bound documents are also acceptable. Use of 3-ring binders is prohibited and will be automatically Rejected and returned to Contractor without review.
- C. Additional copies may be required by individual sections of these Specifications.
- D. Substitution of Equivalent Products: Where individual sections require submittal for substitution of manufacturers and products equivalent to those listed under Manufacturers paragraph, submittals shall be in accordance with that section. Engineer has final authority on equivalence and acceptance.
1. Submittal of Substitution Request Forms are permitted by Prime Bidders only. Substitution Request Forms submitted by a vendor, distributor, or sub-contractor will not be accepted or reviewed.

1.4 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01, indicate installed conditions for:
1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 OPERATION & MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 01 Section "Closeout Procedures" In addition to the requirements specified in Division 01, include the following information for equipment items:
1. Product data for all equipment installed during construction. Product data shall be manufacturer literature, cut-sheets, and/or catalogs and shall clearly depict manufacturer and model number along with standard features and optional features where applicable.
 2. Where available for installed equipment, Contractor shall include manufacturer's published Installation and/or Owner's manuals.
 3. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 4. Programming report/summary for all systems with conditional logic programming (i.e. fire alarm, lighting control system, and PLCs)
 5. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 6. Warranty Information: Copies of documentation for all additional and secondary warranties shall be included.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS (Not Applicable)**PART 3 - EXECUTION****3.1 ROUGH-IN**

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 26 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.
 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 7. Coordinate connection of electrical systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
 8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
 11. Install access panel or doors where units are concealed behind finished surfaces.
 12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
- B. Basis of Design: Where specific systems and products are shown or specified with a Basis of Design, the supporting work and appurtenances are shown and specified uniquely for the Basis of Design. Where systems and products other than the Basis of Design are installed, Contractor shall adjust circuiting, raceway infrastructure, cable type, wire size, supporting means, backbox type, and any other appurtenance as required for a complete, fully functional and operational system or product.

3.3 CUTTING AND PATCHING

- A. General: Perform cutting and patching in accordance with the following requirements:
1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Remove and replace defective Work.
 - b. Remove and replace Work not conforming to requirements of the Contract Documents.

- c. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.
2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Protection of Installed Work: During cutting and patching operations, protect adjacent installations. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 INSPECTIONS

- A. Authority Having Jurisdiction: Notify and schedule all inspections, with a minimum of 10 days notice in writing prior, to the Authority Having Jurisdiction.

END OF SECTION 260100

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SECTION 260500**BASIC ELECTRICAL MATERIALS AND METHODS****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. This Section includes the following:
 - 1. Electrical Equipment Installation.
 - 2. Sleeves and sleeve seals for raceway and cable.
 - 3. Firestopping.
 - 4. Concrete equipment bases.
 - 5. Cutting and patching for electrical construction.
 - 6. Touchup painting.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Electrical equipment shall be new and manufactured within the last 12 months unless otherwise noted and approved by the engineer.

1.4 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in rooms.

- C. Coordinate electrical service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
 - 2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.
- D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 CONCRETE BASES

- A. Concrete Forms and Reinforcement Materials: As specified in Division 03 Section "Cast-in-Place Concrete."
- B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength as specified in Division 03 Section "Cast-in-Place Concrete."

2.3 TOUCHUP PAINT

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations. Provide any additional supporting means not provided by manufacturer to install equipment.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Sleeves for power raceway and cables: Steel, cut sleeves to length for mounting flush with both surfaces of walls.
- F. Sleeves for telecommunication cables: Rigid galvanized steel conduit, extend sleeves 2" on each side of wall. Provide plastic bushing on each end.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.6 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.7 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 09 Section "Interior Painting" and Division 09 Section "Exterior Painting"
 - 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
 - 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
 - 3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 260510

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SECTION 260519**CONDUCTORS AND CABLES****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. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports: Submit all cable tests reports to Engineer ten days prior to Final Inspection.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 CONDUCTORS AND CABLES**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. American Insulated Wire Corp.; a Leviton Company.
 - 2. General Cable Corporation.

3. Southwire Company.
- B. Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.

2.2 CONNECTORS AND SPLICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Thomas & Betts Corporation.
 2. Ideal Industries, Inc.
 3. 3M; Electrical Products Division.
 4. Tyco Electronics Corp.
- B. Description: UL listed, factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated. Splices in solid conductors shall be made using Ideal Wirenuts, 3M Scotchlocks, or T&B Marrette pressure type wire connectors. Permanent crimp connectors are not acceptable.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Minimum Size: No. 12 AWG for power and lighting circuits.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN or XHHW, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN or XHHW, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN or XHHW, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.

- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN or XHHW, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN or XHHW, single conductors in raceway.
 - 1. **Concealed Lighting Branch Circuits:** Type MC cable, #12 AWG, copper conductor, 90°C insulation. May be used for connecting light fixtures together. Maximum length is 15'. **All home runs to first light fixture and switch legs shall be in conduit.** Do not use for receptacle or other power circuits.
 - 2. **Concealed Receptacle Branch Circuits:** Type MC cable, #12 AWG, copper conductor, 90°C insulation. May be used for connecting general purpose receptacles within a single room where concealed in gypsum board walls. **All home runs to first junction box or receptacle within room shall be in conduit.** Do not use in masonry wall construction or for dedicated receptacles or other power circuits.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. **Fire Alarm Circuits:** See Section "Fire Alarm", in raceway.
- J. **Class 1 Control Circuits:** Type THHN-THWN or XHHW, in raceway.
- K. **Class 2 Control Circuits:** Type THHN-THWN or XHHW, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- 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. Voltage Drop: Conductor size shall be increased to account for voltage drop as follows:
 - 1. Where the conductor length from the panel to the first outlet on a 277V circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.

2. Where the conductor length from the panel to the first outlet on a 120V circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG. Increase an additional wire size for every additional 50' to first outlet.
- F. Dedicated Neutrals: Provide dedicated neutral for all single-pole branch circuits, unless otherwise noted on plans. All neutrals shall be uniquely identified at splices or taps to correspond with their ungrounded circuit conductors.
- G. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- H. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Keep conductor splices to a minimum. No feeders shall be spliced. No splicing shall be made except within outlet or junction boxes, troughs, or gutters.
- 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. Splices shall be made using with pre-insulated spring/coil connectors (wire nuts), insulated barrel mechanical lugs, or box mounted insulated terminal strips.
 2. Push-in type, permanent crimp-on type, and split-bolt type are prohibited.
 3. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Testing Technician
 1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.
- C. Tests and Inspections: After installing conductors and cables and before electrical circuitry has been energized, test conductors for compliance with following requirements.
 1. Physical Inspection and Testing
 - a. Verify cable ratings and data correspond to drawings and specifications.

- b. Verify electrical connections are made to provide the electrical system described in the drawings and specifications.
 - c. Confirm bolted electrical connections are low impedance using one of the following means:
 - 1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
 - 2) Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench.
 - d. Inspect cable connectors to verify they are correctly installed.
 - e. Verify all cables are identified and arranged according to the drawings and specifications.
 - f. Verify that all cable jackets and insulation are in good condition and did not sustain damage during installation.
2. Electrical Inspection and Testing
- a. For feeder current-carrying phase conductors and neutrals: test the insulation resistance with respect to ground for one minute. Cables rated for 300 volts shall be tested with 500 volts DC and cables rated for 600 volts shall be tested with 1000 volts DC. All insulation resistance data gathered shall comply with manufacturer's documentation; if documentation does not exist, comply with the values found in Table 100.1 in the ANSI/NETA ATS-2009.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. 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.

END OF SECTION 260519

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SECTION 260526**GROUNDING AND BONDING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS**2.1 CONDUCTORS**

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Cable: stranded conductor sized per NEC 250 requirements.
 - 4. Bonding Conductor: stranded conductor sized per NEC 250 requirements.

5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; sized per NEC 250 requirements.
- C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators and stand-off brackets.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory 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, bolted pressure-type, with at least two bolts.
 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.
- C. Grounding Bus: Install in electrical and telecommunication equipment rooms, in rooms housing service equipment, and elsewhere as indicated. Install bus on insulated spacers 1 inch (25 mm), minimum, with stand-off bracket from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
- D. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Underground Connections: Welded connectors.
 3. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits. The raceway shall not be relied on for ground continuity.
- B. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide a No. 3/0 AWG minimum insulated grounding conductor (Telecommunications Bonding Backbone, TBB) in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Refer to Telecommunications Room Grounding Detail on plans for further requirements.
 - 1. MDF/Headend Room and IDF Rooms: Terminate Telecommunications Bonding Backbone on a grounding bus (Telecommunications Grounding Busbar, TGB). Refer to Telecommunications Room Grounding Detail on plans for requirements.
 - 2. Cabinets, Racks, and Ladder Tray: Extend minimum #10 grounding conductor from equipment to TGB.
 - 3. All telecommunication grounding shall be performed in compliance with TIA/EIA 607 Standard – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

3.3 INSTALLATION

- A. Grounding Conductors: 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. Ground Rods: Drive rods until tops are 6 inches (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.
- C. 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 any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
 - 3. Provide exothermic-welded connection to building structural steel.
 - 4. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding Bushings and Jumpers: Boxes provided with concentric, eccentric or over-sized knockouts shall be provided with bonding bushings and jumpers lugged to box.
- E. 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a 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 and Backflow Preventer Piping: Use braided-type bonding jumpers to electrically bypass water meters and backflow preventers where located inside the building. Connect to pipe with a bolted connector.
- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
- B. Testing Technician
1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.
- C. Physical Inspection and Testing
1. Inspect grounding system to verify that it complies with the requirements in the drawings and specifications, as well as, NFPA 70 *National Electric Code Article 250*.
 2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards. All portions of the grounding system shall be free of corrosion.
 3. Confirm bolted electrical connections are provided with high impedance using one of the following means:
 - a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
 - b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench.
 4. Verify that adequate anchorage is in place for the grounding system.

D. Electrical Inspection and Testing

1. Conduct tests for fall of potential as defined by ANSI/IEEE 81 on the grounding system.
2. Determine the resistance to ground throughout grounding system including equipment frames, systems neutral, and equipment grounding bars. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform ground resistance in all of, but not limited to, the areas listed below:
 - a. Main electrical distribution ground bar: 15 ohms
 - b. Main telecommunications ground bar: 15 ohms

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

1. Retest required to show compliance with above value.

F. Remove and replace malfunctioning units and retest as specified above.

G. 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.

END OF SECTION 260526

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SECTION 260529**HANGERS AND SUPPORTS****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. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Hangers and supports require Seismic Controls. Equipment is required to be certified by the manufacturer. Engineer has delegated design of controls for mounting and supports to Contractor.
 - 1. Delegated Design: Design supports, mounting, and associated raceway supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 2. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".
 - 3. Structural Performance: Supports, mounting, and associated raceway supports shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE 7.
 - a. Seismic Loads: Refer to Specification Section 260548.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 SUBMITTALS

- A. Product Data: For anchors, supports, and slotted channel/strut systems.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS**2.1 COATINGS**

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.2 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: Clevis hangers, riser clamps, two-hole conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps as described in NECA 1 and NECA 101.
- B. Fasteners: Types, materials, and construction features as follows:
 - 1. Expansion Anchors: Carbon steel wedge or sleeve type for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Powder-Driven Threaded Studs: Heat-treated steel for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 3. Toggle Bolts: All steel springhead type.
 - 4. Hanger Rods: Threaded steel.
- C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

- D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.
- E. U-Channel Systems: Comply with MFMA-4, factory-fabricated components for field assembly; 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.3 FABRICATED SUPPORTING DEVICES

- A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.
- B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with the building structural system and with other electrical installation.
- C. Raceway Supports: Comply with the NEC and the following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs. safety allowance in the strength of each support.
 - 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing. Spring steel fasteners are not permitted for use where exposed.

6. Support raceways installed on interior of exterior building walls a minimum of $\frac{1}{4}$ inch from wall surface using "clamp-back" struts.
 7. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
 8. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
 9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals. Spring steel fasteners are not permitted for use in vertical runs. Support individual vertical runs using two-hole straps. Support parallel runs of vertical raceway together on channel using bolted clamps.
- D. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- E. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.
- F. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:
1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
 2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
 3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS**HORIZONTAL RUNS**

<u>Raceway Size (Inches)</u>	<u>No. of Conductors in Run</u>	<u>Location</u>	<u>RMC & IMC (1)</u>	<u>EMT (1)</u>	<u>OFR (1)</u>
1/2, 3/4	1 or 2	Flat ceiling or wall.	5	5	5
1/2, 3/4	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	7	7	5
1/2, 3/4	3 or more	Any location.	7	7	...
1/2-1	3 or more	Any location.			
1 & larger	1 or 2	Flat ceiling or wall.	6	6	...
1 & larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction.	10	10	5
1 & larger	3 or more	Any location.	10	10	...
Any		Concealed.	10	10	...

VERTICAL RUNS

<u>Raceway Size (Inches)</u>	<u>No. of Conductors in Run</u>	<u>Location</u>	<u>RMC & IMC (1, 2)</u>	<u>EMT (1)</u>	<u>OFR (1)</u>
1/2, 3/4		Exposed.	7	7	...
1, 1-1/4		Exposed.	8	8	...
1-1/2 and larger		Exposed.	10	10	...
Up to 2		Shaftway.	14	10	...
2-1/2		Shaftway.	16	10	...
3 & larger		Shaftway.	20	10	...
Any		Concealed.	10	10	5

NOTES:

- (1) Support spacing listed in feet. Maximum spacing of supports 10 feet.
 (2) Maximum spacing for IMC above apply to straight runs only.
 Otherwise the maximums for EMT apply.

Abbreviations: EMT Electrical metallic tubing.
 IMC Intermediate metallic conduit.
 RMC Rigid metallic conduit.
 OFR Optical Fiber Raceway.

END OF SECTION 260529

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SECTION 260533**RACEWAY AND BOXES****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. This Section includes interior and exterior raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RNC: Rigid nonmetallic conduit.
- F. RSC: Rigid steel conduit.

1.4 SUBMITTALS

- A. Product Data: For raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 METAL CONDUIT AND TUBING**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 2. O-Z Gedney; a unit of General Signal.
 - 3. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Aluminum Rigid Conduit: ANSI C80.5.
- D. IMC: ANSI C80.6.
- E. EMT: ANSI C80.3.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Plated-steel hexagonal compression type. Cast, pot metal, set-screw, or crimp type fittings are not acceptable.
 - a. Couplings shall be "concrete tight" where concealed in masonry.
 - b. Box connectors shall be insulated throat type.
- H. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Arncor Corporation.
 - 3. Lamson & Sessions; Carlon Electrical Products.
 - 4. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.

- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: UL 1660.
- E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Arnco Corporation.
 - 2. Endot Industries Inc.
 - 3. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 METAL WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
 - 4. Austin Electrical Enclosures
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.

2. EGS/Appleton Electric.
 3. Hoffman.
 4. RACO; a Hubbell Company.
 5. Thomas & Betts Corporation.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular. See details on plans.
1. All floor boxes shall meet UL scrub water exclusion requirements.
- E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
- F. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.

2.6 FLAT PANEL DISPLAY WALL BOX

- A. Classification and Use: Wall box system is to be utilized in dry, interior locations only as defined by Article 300-15 of the National Electrical Code (NEC). Wall Box shall be by Underwriters Laboratories Inc. to U.S.
- B. General: Wall Boxes shall provide the interface between power, communication and audiovisual (A/V) cabling where power and communication and/or A/V device outlets are required. Boxes shall provide recessed device outlets that will not obstruct the wall area. Refer to Drawings for size and types.
- C. Wall boxes shall allow all wiring to be completed at box level.
- D. Box shall be provided with the following features:
1. Dimensions: 11.25"W x 4"D x 11.5"H
 2. Finish: Shall be selected and coordinated with architect.
 3. Devices: Refer to details on drawings for types and quantities.

2.7 AUDIOVISUAL WALL BOX

- A. Classification and Use: Wall box system is to be utilized in dry, interior locations only as defined by Article 300-15 of the National Electrical Code (NEC). Wall Box shall be by Underwriters Laboratories Inc. to U.S.
- B. General: Wall Boxes shall provide the interface between power, communication and audiovisual (A/V) cabling where power and communication and/or A/V device outlets are required. Boxes shall provide access to system cabling and shall not obstruct the wall area. Refer to Drawings for size and types.
- C. Wall boxes shall allow all wiring to be completed at box level.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. Fiberglass Reinforced Concrete Handholes: Constructed of polymer concrete and reinforced by heavy-weave fiberglass. Composite material shall be rated for no less than 8,000 lbs. Over a 10"x10" area and tested to temperatures of -50°F. Compressive strength should be no less than 11,000 psi. Covers shall have a minimum coefficient of friction of .5 and have a design load of minimum 15,000 lbs per 10"x10" area. Unit, when buried, shall be designed to support AASHTO H10 loading.
- B. Cover Legend: "ELECTRIC" or "COMMUNICATIONS" accordingly.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit.
 - 2. Concealed Conduit, Aboveground: Rigid steel conduit.
 - 3. Underground Conduit & Duct:
 - a. Service Entrance: RNC, Type EPC-40-PVC, concrete encased.
 - b. Feeders: RNC, Type EPC-40-PVC, concrete encased.
 - c. Branch Circuit: RNC, Type EPC-40-PVC, direct buried.
 - d. Telecommunications: RNC, Type EPC-40-PVC, concrete encased.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Indoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed and Subject to Physical Damage: Rigid steel conduit.
 - a. Exposed conduit routed vertically and horizontally below 8' above finished floor in mechanical, electrical, and telecom rooms is considered subject to physical damage.

- b. Exposed conduit routed vertically up through floor slabs shall be considered subject to physical damage until it reaches 8' above finished floor or enters a box, cabinet, or enclosure.
 - c. Exposed conduit routed down vertically from above 8' which enters boxes, cabinets, or enclosures mounted 48" to top above finished floor or higher is not considered exposed and subject to physical damage and EMT may be used.
- 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
- 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
- 5. Damp or Wet Locations: Rigid steel conduit.
- 6. Raceways for Optical Fiber or Communications Cable: Plenum-type, optical fiber/communications cable raceway.
- 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
- 8. Raceway Color Coding: Apply color coding to both concealed raceway in all locations and exposed raceway in non-finished areas.
 - a. Fire Alarm Raceway: EMT raceway containing fire alarm wiring shall have a factory applied **red** color finish.
 - b. Telecom & A/V Raceway: EMT raceway containing telecom and A/V raceway wiring shall have a factory applied **blue** color finish.
 - c. Security System Raceway: EMT raceway containing telecom and A/V raceway wiring shall have a factory applied **black** color finish.
 - d. HVAC Controls Raceway: EMT raceway containing HVAC controls wiring shall have a factory applied **yellow** finish.
 - e. Emergency Feeder/Branch Circuit Raceway: EMT raceway containing emergency wiring shall have a factory applied **orange** finish.
 - f. Rigid steel conduit used for the above systems shall be field painted to match corresponding EMT Finish.
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.
- B. Minimum Raceway Size:
 - 1. Interior: 3/4-inch trade size, unless otherwise noted.
 - 2. Exterior, below grade: 1-inch trade size.
- C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

- D. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- E. Install raceways level and square and at proper elevations. Provide adequate headroom.
- F. Complete raceway installation before starting conductor installation.
- G. Support raceways as specified in Division 26 Section "Supporting Devices."
- H. Use temporary closures to prevent foreign matter from entering raceways.
- I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
- J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
- K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.
- L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.
- M. Raceways Embedded in Concrete Slabs: Raceway shall not be installed embedded within floor and roof slabs, except where connecting to floor boxes. Install in middle third of slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.
 - 1. All raceway embedded in slabs shall be rigid galvanized steel conduit.
 - 2. Raceway shall extend a maximum of 24" from floor box before offsetting beneath slab. Raceway shall extend 12" from penetration of floor slab before transitioning back to electrical metallic tubing.
 - 3. Space raceways laterally to prevent voids in concrete.
 - 4. Run conduit parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 5. Roofing slab: Raceway shall not be embedded in roofing slabs.
 - 6. Raceway installed in vertical concrete wall shall be rigid galvanized steel conduit and comply with requirements for installation in slabs.
- N. Raceways Installed in Load Bearing Masonry: Raceways installed in load bearing masonry shall be either rigid galvanized steel conduit or coated EMT specifically rated and listed for installation in concrete.
- O. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
 - 1. Run parallel or banked raceways together, on common supports where practical.

2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- P. Join raceways with fittings designed and approved for the purpose and make joints tight.
1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 2. Use insulating bushings to protect conductors.
- Q. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.
1. Where concentric, eccentric, or over-sized knock outs are encountered, a grounding-type insulated bushing shall be provided.
- R. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.
- S. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.
- T. Telecommunications Stub-ups & Sleeves: Provide plastic bushings on all conduit stub-ups and sleeves.
- U. Telecommunications Raceways, 4-Inch Trade Size (DN53) and Smaller: In addition to the above requirements, install raceways in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes sized per BICSI's Telecommunications Distribution Methods Manual where necessary to comply with these requirements. All bends shall be sweeping long radius manufactured elbows.
1. Type LB and similar conduit fittings are not permitted for use with any telecommunications raceways.
 2. Flexible metal conduit (FMC) is not permitted for use as a telecommunications raceway.
- V. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.

2. Where otherwise required by NFPA 70.
- W. Stub-up Connections: Where underground raceways are required to turn up into equipment, cabinets, etc., the elbow and stub-up shall be rigid steel. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.
- X. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
- Y. Set floor boxes level and adjust to finished floor surface.
- Z. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Division 31 Section "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
 4. Install manufactured rigid steel conduit elbows for stub-ups at equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
- B. Concrete-Encased Conduit/Duct:
 1. For electrical-power duct banks, note that ampacity of cables may be reduced in duct banks of more than two tiers of two ducts each.
 2. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
 3. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use long sweep bends with a minimum radius of 25 feet, both horizontally and

- vertically, at other curve locations unless otherwise indicated. Use manufactured long sweep bends with a minimum radius of 48 inches only where indicated.
4. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
 5. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 8 inches o.c. for 4-inch ducts, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to end-bell spacing 10 ft. (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
 - b. Grout end bells into structure walls from both sides to provide watertight entrances.
 6. Coordinate design of concrete-encased duct banks approaching building wall penetrations with building structural design to support ducts at wall without reducing structural or watertight integrity of building. Do not use steel conduit in highly corrosive soils. Coordinate with Drawings.
 7. Sleeves and sleeve seals for conduits penetrating building walls below grade are specified in Division 26 Section "Common Work Results for Electrical."
 8. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 5 ft. (1.5 m) outside the building wall without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results for Electrical."
 9. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
 10. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
 11. Concrete-Encased Ducts: Support ducts on duct separators.
 - a. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 ft. (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric or plastic straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - b. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - 1) Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
 - 2) If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
 - c. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to

direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

- d. Reinforcement: Reinforce concrete-encased duct banks. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - e. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 - f. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 - g. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at equipment and at building entrances through the floor.
 - 1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - 2) Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
12. Warning Tape: Provide underground-line warning tape specified in Division 26 Section "Electrical Identification." Install 6 to 8" below finished grade.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 FIRESTOPPING

- A. 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 "Penetration Firestopping."

3.6 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 26 05 48**SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Restraint channel bracings.
 - 2. Restraint cables.
 - 3. Seismic-restraint accessories.
 - 4. Mechanical anchor bolts.
 - 5. Adhesive anchor bolts.
- B. Related Requirements:
 - 1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.
 - 2. Section 265100 "Lighting" for specific requirements for emergency lighting.
 - 3. Section 268311 "Fire Alarm" for specific requirements for fire alarm systems.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Z e Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
- B. Delegated-Design Submittal: For each seismic-restraint device.
 - 1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints, wind restraints and for designing vibration isolation bases.

- a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
- 3. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- D. Qualification Data: For professional engineer and testing agency.
- E. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Wind-Restraint Loading:
1. Ultimate Wind Speed (3 second gust): **135 mph (Wilmington, NC).**
 2. Assigned Occupancy Category: **III.**
 3. Minimum **20 lb/sq. ft.** multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
1. Site Class as Defined in the IBC: **D.**
 2. Seismic Design Category: **C.**
 3. Assigned Occupancy Category as Defined in the IBC: **III.**
 - a. Component Importance Factor: See Chart Below.

Component	I _p	Restraints Required
Emergency & LRS Systems Raceway and Cable	1.5	YES
Emergency Lighting Equipment, Including Inverters	1.5	YES
Emergency Generators	1.5	YES
Emergency & LRS Automatic Transfer Switches	1.5	YES
Emergency & LRS Distribution Equipment	1.5	YES
Fire Alarm System Raceway and Cable	1.5	YES
Fire Alarm System Equipment	1.5	YES
Normal & OS Systems Raceway and Cables	1.0	NO
Normal & OS Lighting Equipment	1.0	NO
Normal & OS Distribution Equipment, Including ATS	1.0	NO
All other Division 26 Systems	1.0	NO

Note: LRS = Legally Required Standby, OS = Optional Standby

- b. Component Response Modification Factor: In accordance with ASCE 7.
 - c. Component Amplification Factor: In accordance with ASCE 7.
4. Design Spectral Response Acceleration at Short Periods (0.2 Second): **0.218g.**
 5. Design Spectral Response Acceleration at 1.0-Second Period: **0.091g.**
 6. Rated strengths, features, and applications shall be defined in reports by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to Authority Having Jurisdiction.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four (4) times the maximum seismic forces to which they are subjected.

2.2 RESTRAINT CHANNEL BRACINGS

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

- A. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Either Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- C. 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.
- D. 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.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.6 ADHESIVE ANCHOR BOLTS

- A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.
- B. Equipment and Hanger Restraints:
 - 1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, or an agency acceptable to authorities having jurisdiction providing required submittals for component.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. 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.
- 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. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.

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

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: **Owner will engage** a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least **four** of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
- C. Seismic controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48

SECTION 260553**IDENTIFICATION FOR ELECTRICAL SYSTEMS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of all electrical equipment and system components used in identification signs and labels. Schedule shall depict preliminary printouts of proposed equipment labels for review prior to order.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with ANSI A13.1 and NFPA 70 for color-coding.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS**2.1 RACEWAY AND CABLE LABELS**

- A. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

- B. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.
 - 1. Not less than 6 inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend indicating type of underground line.
- C. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- D. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.2 NAMEPLATES AND SIGNS

- A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.
- B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Punched or drilled for mechanical fasteners.
- C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.
- E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength: 50 lb (22.3 kg) minimum.
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: According to color-coding.
- B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
 1. General 120/208V Equipment: Black label with white core.
 2. Emergency Distribution Equipment: Orange label with white core.
 3. Fire Alarm Equipment: Red label with white core.
 4. Voice, Data & Video Systems: Blue label with white core.
 5. Security Systems: Burgundy label with white core.
- C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
- E. Install painted identification according to manufacturer's written instructions and as follows:
 1. Clean surfaces of dust, loose material, and oily films before painting.
 2. Prime surfaces using type of primer specified for surface.
 3. Apply one intermediate and one finish coat of enamel.
- F. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below. Banding of colored conduit is not required.
 1. Bands: Pre-tensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
 2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas. Also provide color banding at outlet box stub-ups.
 3. Apply the following colors to the systems listed below:
 - a. Fire Alarm System: Red.

- b. Telecom (Intercom, Data, Video) Systems: Blue.
 - c. Security (CCTV, Intrusion Detection) System: Burgundy.
 - d. Emergency Systems: Orange.
- 4. Color code cover of raceway junction boxes following the colors listed above.
- 5. Spare raceway for future use shall be identified as such and shall indicate where raceway originates and terminates on each end.
- G. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- H. Circuit Identification Labels on Outlet Boxes, Junction Boxes and Pull Boxes: Install labels externally.
 - 1. Outlet boxes (receptacles and switches) and exposed junction boxes: Pressure-sensitive, self-adhesive plastic label on faceplate. Use clear label with black letters.
 - 2. Concealed junction and pull boxes: Neat handwritten label using permanent black marker.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
 - 4. Future Use Circuits: Circuits for future use shall be identified as such and list panel and circuit number of source.
- I. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.
 - 1. Color-code 208/120-V system as follows:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 2. Factory apply color the entire length of all conductors, except the following field-applied, color-coding methods may be used instead for service conductors:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- (25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
 - b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches (76 mm) from the terminal and spaced 3 inches (76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
- J. Apply identification to conductors as follows:
 - 1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 - 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.

3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- K. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- L. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. Locate label on exterior of any enclosure. This includes power, lighting, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide three lines of text with 1/4-inch high lettering on 1-1/2-inch high label; where four lines of text are required, use labels 2 inches high. Use surface and core colors as listed in Part 2 above. Provide labels for all electrical equipment listed below. In general, all labels shall include riser diagram ID, amperage, voltage, number of phases/poles, and equipment served from (source). Provide additional information as listed below:
1. Panelboards: MCB/MLO.
 2. Disconnect switches: equipment served by.
 - a. Provide label for all disconnects provide by Division 23, 24 or 26.
 3. Enclosed circuit breakers: equipment served by.
 - a. Provide label for all disconnects provide by Division 23, 24 or 26.
 4. Contactors & Relay Panels.
 5. Fire Alarm Control Panel and auxiliary power supplies and enclosures.
 6. Service Entrances: Provide placard at service entrance disconnects indicating maximum fault current and date of calculation per NEC Article 110.24. Maximum fault current shall be coordinated with utility and placard installed prior to energization

END OF SECTION 260553

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SECTION 260923**LIGHTING CONTROL DEVICES****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. This Section includes the following lighting control devices:
 - 1. Photoelectric switches.
 - 2. Standalone daylight-harvesting switching and dimming controls.
 - 3. Occupancy sensors.
 - 4. Switchbox-mounted occupancy sensors.
 - 5. Digital timer light switches.
 - 6. Lighting contactors.
 - 7. Emergency lighting transfer devices.
- B. Related Sections include the following:
 - 1. Division 26 Section "Addressable Dimming Control System" for low-voltage, programmable lighting and dimming control system. Occupancy sensors associated with Addressable Dimming Control System are separate and distinct from the general purpose occupancy sensors specified in this section.
 - 2. Division 26 Section "Relay Lighting Control Systems" for low-voltage, programmable relay based lighting control systems.
 - 3. Division 26 Section "Wiring Devices" for wall-box dimmers, occupancy sensors, and manual light switches.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

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

1. Show installation details for the following:
 - a. Photoelectric switches.
 - b. Daylight-harvesting sensors.
 - c. Occupancy and Vacancy sensors.
 - d. Lighting contactors.
- C. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

- 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 system, and partition assemblies.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Leviton Mfg. Company Inc.
- B. Description: Solid state, with SPST dry contacts rated for 1800 VA inductive, to operate connected load, complying with UL 773, and compatible with ballasts and LED lamps.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 3. Time Delay: Thirty-second minimum, to prevent false operation.
 4. Lightning Arrester: Air-gap type.
 5. Mounting: Twist lock complying with NEMA C136.10, with base.
 6. Failure Mode: Luminaire stays ON.

2.2 DAYLIGHT-HARVESTING SWITCHING CONTROLS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Hubbell Lighting.
 - 2. Leviton Mfg. Company Inc.
 - 3. Novitas, Inc.
 - 4. Watt Stopper (The).
 - 5. Lutron Electronics Inc.
- B. System Description: System operates indoor lighting.
- C. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.
 - 1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present.
 - b. When significant daylight is present (target level).
 - c. System programming is done with two hand-held, remote-control tools.
- D. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with integrated power pack, that detects changes in indoor lighting levels that are perceived by the eye.
- E. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg.
 - 3. Sensor Output: Contacts rated to operate the associated power pack, complying with UL 773A. Sensor shall be powered by the power pack.
 - 4. Sensor Output: Digital signal compatible with power pack.
 - 5. Sensor type: Closed loop.
 - 6. Zone: Single.
 - 7. Power Pack: Dry contacts rated for 20-A, LED load at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 - a. LED status lights to indicate load status.
 - b. Plenum rated.
 - 8. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
 - 9. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
 - 10. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.

11. Test Mode: User selectable, overriding programmed time delay to allow settings check.
12. Control Load Status: User selectable to confirm that load wiring is correct.
13. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Novitas, Inc.
 4. Watt Stopper (The).
 5. Lutron Electronics Inc.
- B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
 2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
- C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated power pack, to detect changes in indoor lighting levels that are perceived by the eye.
- D. Electrical Components, Devices, and Accessories:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
 3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.
- E. Power Pack: Dry contacts rated for 20-A LED load at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
1. LED status lights to indicate load status.
 2. Plenum rated.

2.4 OCCUPANCY SENSORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Novitas, Inc.
 4. Watt Stopper (The).
 5. Lutron Electronics Inc.
- B. Wall-box Line Voltage Occupancy Sensor: Wall-box, solid-state units with integral relay.
1. Basis of Design: Wattstopper PW-200.
 2. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 5 to 45 minutes. Capable of being set to either automatic on or manual on.
 3. Must be capable of controlling lighting and fans for bathroom exhaust.
 4. PIR Type: Detect occupancy by sensing a combination of heat and movement in area of coverage.
 - a. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of at least 36 sq. in.
 5. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
 6. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 7. Mounting: Suitable for mounting in a standard outlet box.
 8. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 9. On/Bypass Switch: Provides manual on function or overrides the automatic on function in case of sensor failure.
- C. Ceiling & Wall Mount Low-Voltage Occupancy Sensor: Ceiling or wall mounted 24-volt occupancy sensors with separate relay/power pack.
1. Basis of Design:
 - a. Spaces Less than 1000 square feet: Lutron #LOS-CDT-1000-WH
 - 1) Area of Major Motion Detection: 23'x23'.
 - 2) Area of Minor Motion Detection: 32'x32'.
 - b. Spaces Greater than 1000 square feet: Lutron #LOS-CDT-2000-WH.
 - 1) Area of Major Motion Detection: 45'x23'.
 - 2) Area of Minor Motion Detection: 64'x32'.
 2. Sensors shall be dual technology and utilize both infrared and ultrasonic sensing mechanisms.
 - a. Passive infrared sensor shall have a multiple segmented lens, with internal grooves to eliminate dust and residue build-up.

- b. Ultrasonic sensor shall have an operating frequency of 32kHz or 40kHz, that shall be crystal controlled to within plus or minus 0.005% tolerance to assure reliable performance and eliminate sensor cross talk. Sensors using multiple frequencies are not acceptable.
 - c. Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space.
 - d. Sensors shall have optional readily accessible, user adjustable controls for time delay and sensitivity that can override any adaptive features.
- 3. All sensors shall provide a method of indication to verify that motion is being detected during testing and that the unit is working. There shall be different indicators for infrared and ultrasonic technologies.
- 4. Controls shall incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
- 5. Power pack shall be able to mount in junction box, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer shall provide power to a minimum of three (3) sensors
 - a. Power pack shall be plenum rated
- 6. Control wiring between sensors and control units shall be Class 2, 18-24 AWG, stranded U.L. Classified, PVC insulated or TEFLON jacketed cable in conduit.

2.5 DIGITAL TIMER LIGHT SWITCHES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Hubbell Lighting.
 - 2. Leviton Mfg. Company Inc.
 - 3. Novitas, Inc.
 - 4. Watt Stopper (The).
 - 5. Lutron Electronics Inc.
- B. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 20 minute increments.
 - 1. Rated 10 A at 120-V ac for LED.
 - 2. Integral relay for connection to BAS.
 - 3. Voltage: 120 V.
 - 4. Color: White.
- C. Faceplate: Color matched to switch.

2.6 LIGHTING CONTACTORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Eaton Electrical Inc.; Cutler-Hammer Products.
 2. GE Industrial Systems; Total Lighting Control.
 3. Siemens Energy & Automation, Inc.
 4. Square D; Schneider Electric.
- B. Description: Electrically operated and mechanically held, combination type, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 2. Enclosure: Contactors shall be mounted in NEMA 1 enclosure where located indoors and in NEMA 4 enclosure where located outdoors or in damp or wet locations.
 3. Provide hand-off-auto selector switch mounted through enclosure door.
 - a. Selector switch is not required for contactors used for emergency power off controls.
 4. Control Coil Voltage: Match control power source, unless otherwise noted on plans.

2.7 EMERGENCY LIGHTING TRANSFER DEVICES

- A. Description: Emergency lighting transfer device shall transfer a lighting load from normal power to generator or central inverter system power when normal power is lost and shall bypass any local wall switch or occupancy sensor to allow generator- or central inverter system-supplied lighting loads to energize when normal power is lost. Transfer device shall comply with UL 924.
- B. Single Fixture Device: Transfer device designed to provide emergency transfer to a single fluorescent fixture or ballast within fixture. Device housing shall be designed to be installed within fixture ballast channel.
1. Basis of Design: Bodine GTD
- C. Branch Circuit Device: Transfer device designed to provide emergency transfer to a 20A lighting branch circuit. The device shall consist of relay switching circuitry, a test switch, a normal power indicator light and an alternate power indicator light contained within a wall mount enclosure.
1. Basis of Design: Bodine GTD20A.

PART 3 - EXECUTION**3.1 SENSOR INSTALLATION**

- A. Comply with NECA 1. 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 written instructions.

3.2 CONTACTOR INSTALLATION

- 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.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Conductors and Cables."
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors and branch circuit emergency lighting transfer devices.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work. Repair, or replace, and retest.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 260923

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SECTION 260934**ADDRESSABLE DIMMING LIGHTING CONTROL SYSTEM****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the requirements for a distributed dimming lighting control system. System controls dimmable lighting fixtures from low voltage wall stations, occupant sensors, daylight sensors and wireless handheld transmitters. System includes bus supplies, low voltage wall stations, control interfaces, sensors, personal control infrared transmitters, fluorescent dimming ballasts, and handheld lighting control programmers and programmer software. System is configured using a wireless handheld lighting control programmers and software.
- B. Related Sections include the following:
 - 1. Division 26 Section "Lighting Control Devices" for general purpose occupancy sensors.
 - 2. Division 26 Section "Relay Lighting Control Systems" for low-voltage, programmable relay based lighting control systems.
 - 3. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. RFI: Radio-frequency interference.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.
- F. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting control system, bus supply, control station, sensor, interface and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each lighting control system and related equipment.
 - 1. System Riser Diagram: Schematic of complete system wiring between components. All system components, including light fixtures, shall be shown on system riser diagram.
 - 2. Component Wiring Diagrams: Schematic of system wiring differentiating between power and control wiring.
- C. Maintenance Data: For lighting control system and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout", include the following:
 - 1. Manufacturers' written installation guidelines.
 - 2. Final system wiring diagrams, load schedules, and zone schedules.
 - 3. Copy of facility programming set points.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.
- D. Comply with Underwriters Laboratories, Inc. (UL) 508 - Standard for Industrial Control Equipment and 1472 - Solid-State Dimming Controls.

1.6 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
 - 1. Ambient temperature: 0° to 40° C (32° to 104° F).
 - 2. Relative humidity: Maximum 90 percent, non-condensing.
 - 3. Lighting control system must be protected from dust during installation.

1.7 WARRANTY

- A. Special Warranty for Lighting Control System: Provide manufacturer's written warranty covering two-year parts and labor to repair and replace defective equipment from date of Final Acceptance.

1.8 COORDINATION

- A. Coordinate layout and installation of lighting control system components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers' offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Addressable Dimming Lighting Control System:
 - 2.
 - a. Lutron Electronics, Inc.
 - b. Crestron Electronics
 - c. Leviton Mfg. Co., Inc.
 - d. Lightolier: A Phillips Group.

2.2 SYSTEM GENERAL REQUIREMENTS

- A. Basis of Design: Lutron EcoSystem
- B. General Performance:
 - 1. Based on integrated control requirements, system shall control lighting with the following hierarchy:
 - a. Emergency (Highest priority): Ignores all other inputs.
 - b. Programming: During system programming, sensor inputs are ignored.
 - c. Occupant sensor: Allows lights to be on/off.
 - d. Daylight sensor: Imposes a high end limit for light output.
 - e. Personal control: Fine tune light levels up to the daylight sensor limit.
 - 2. Each light fixtures response shall be capable of being software assigned to any sensor on the system. Response to a single sensor shall be unique on fixture by fixture basis.
 - 3. Power failure recovery – All devices return to their previous light level prior to power loss.
 - 4. All programmable devices have integral power failure memory to maintain settings for a minimum of 10 years during power loss.
 - 5. Wall station and sensor replacement shall not require programming.

2.3 BUS SUPPLY

- A. General

1. Connect without interface to:
 - a. Occupancy sensors.
 - b. Building management / integration contact closure outputs.
 - c. Fire alarm or security system contact closures.
 - d. Emergency lighting interface [Lutron LUT-ELI] listed to UL 924.
 2. Integral fault protection to prevent bus supply failure in the event of a mis-wire.
 3. LED status indicators:
 - a. Bus supply is powered.
 - b. Bus supply operating properly.
 - c. Bus communication.
 - d. Emergency condition active / non-active.
 4. Configuration switches:
 - a. Override bus to full light output.
 - b. Override bus to low end.
 - c. Override bus to off.
 - d. Closure inputs normally open/closed.
 5. Enable/disable system programming (lockout).
- B. Wall Mounted Enclosure: Provide digital bus power supply in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.

2.4 DIGITAL ADDRESSABLE DRIVER

- A. Digital addressable driver shall provide the following features:
1. Microprocessor control and integral thermal management
 2. Continuous, flicker-free dimming from 100% to 1% relative light output.
 3. Connect without interface to:
 - a. Occupant sensor (motion detector).
 - b. Daylight sensor.
 - c. Personal control input (keypad or infrared receiver).
 4. Minimum of 50,000 hours of lifetime.
 5. Provide a 0-10 VDC source to power connected sensors.
 6. PELV rated output.
 7. Lights automatically return to the setting prior to power interruption.
 8. Each driver responds independently to:
 - a. Up to 64 occupant sensors.
 - b. Up to 64 personal control inputs.
 - c. 2 daylight sensors.
 9. Averages 2 independent daylight harvesting inputs internally.
 10. Responds to digital load shed command.
 - a. Sets high end trim.
 - b. Automatically scales light output proportional to load shed command.
 - 1) Example: If light output is at 30% and a load shed command of 10% is received, the ballast automatically sets the maximum light output at 90% and lowers current light output by 3% to 27%.

2.5 LOW-VOLTAGE WALL STATIONS

A. General:

1. Class 2 (low voltage).
2. Immediate local LED response upon button activation to indicate that a system command has been requested.
3. Wall stations can be replaced without reprogramming.
4. Color: White

B. One Button Control

1. Toggle on/off and master raise/lower control for group of fixtures.
2. "Press and Hold" button programming for creating and modifying groups.

C. Four Button Control

1. Recall 4 scene for on or all off for one group of fixtures.
2. Master raise/lower control entire group of fixtures.
3. "Press and Hold" button programming supports:
 - a. Create and modify groups.
 - b. Modify scene levels.

2.6 SENSORS

A. General:

1. Use Class 2 wiring for low voltage communication.
2. Can be replaced without reprogramming.
3. Color: White
4. Mountable on lighting fixtures or recessed acoustical ceiling tiles.

B. Infrared Receivers have 360 degree reception of wireless infrared remote controls.

1. Immediate local LED response upon reception of hand held transmitter communication.

C. Interior Daylight Sensors

1. Open-loop or closed loop basis for daylight sensor control scheme (depending on manufacturer).
2. Stable output over temperature from 0° to 40° C.
3. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
4. Provide linear response from 0 to 500 foot-candles.
5. Integral IR receiver for programming.

D. Ceiling & Wall Mount Low-Voltage Occupancy Sensor: Ceiling or wall mounted 24-volt occupancy sensors with second contact closure output.

1. Basis of Design:
 - a. Spaces Less than 1000 square feet: Lutron #LOS-CDT-1000R-WH

- 1) Area of Major Motion Detection: 23'x23'.
 - 2) Area of Minor Motion Detection: 32'x32'.
 - b. Spaces Greater than 1000 square feet: Lutron #LOS-CDT-2000R-WH.
 - 1) Area of Major Motion Detection: 45'x23'.
 - 2) Area of Minor Motion Detection: 64'x32'.
2. Sensors shall be dual technology and utilize both infrared and ultrasonic sensing mechanisms.
 - a. Passive infrared sensor shall have a multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - b. Ultrasonic sensor shall have an operating frequency of 32kHz or 40kHz, that shall be crystal controlled to within plus or minus 0.005% tolerance to assure reliable performance and eliminate sensor cross talk. Sensors using multiple frequencies are not acceptable.
 - c. Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space.
 - d. Sensors shall have optional readily accessible, user adjustable controls for time delay and sensitivity that can override any adaptive features.
3. All sensors shall provide a method of indication to verify that motion is being detected during testing and that the unit is working. There shall be different indicators for infrared and ultrasonic technologies.
4. Controls shall incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
5. Connect directly to ballast, modules, and bus supply without the need of a power pack or other interface.

2.7 HAND HELD PROGRAMMER

A. General

1. Wireless programming for all system settings.
2. Secured via pass code.
3. Replace driver via serial number.
4. Only operates as a lighting control device.
5. Non-volatile memory stores lighting control software for minimum of 10 years for power loss.
6. Stores not system specific configuration settings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment in accordance with manufacturer's installation instructions.
- B. Provide complete installation of system in accordance with Contract Documents.
- C. Provide equipment at locations and in quantities indicated on Drawings. Provide any necessary additional equipment required to provide control intent.

- D. Ensure that daylight sensor placement minimizes sensors view of electric light sources; ceiling mounted and fixture-mounted daylight sensors shall not have direct view of luminaries.

3.2 CONTROL WIRING INSTALLATION

- A. Install wiring between sensing and control devices according to manufacturers' written instructions and as specified in Division 26 Section "Conductors and Cables" for low-voltage connections and Division 26 Section "Telecommunications Cabling Infrastructure" for digital circuits.
- B. Bundle, train, and support wiring in enclosures.
- C. Ground equipment.
- D. Connections: Tighten electrical connectors and terminals according to manufacturers' published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification".

3.4 FIELD QUALITY CONTROL

- A. Provide factory-certified field service engineer to ensure proper system installation and operation under following parameters:
 - 1. Qualifications for factory-certified field service engineer:
 - a. Minimum experience of 2 years training in the electrical/electronic field.
 - b. Certified by the equipment manufacturer on the system installed.
 - 2. Site visit activities:
 - a. Verify connection of power feeds and load circuits.
 - b. Verify connection of controls.
 - c. Verify system operation control by control, circuit by circuit.
 - d. Obtain sign-off on system functions.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain television equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for operation, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.

3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
4. Conduct a minimum of four hours' training for up to four people. Engineer, at their option, may attend the training session.

3.6 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested by Owner within one year of date of Substantial Completion, provide on-site assistance in tuning and adjusting the system to suit actual occupied conditions and to optimize performance, including system programming. Provide up to (4) eight hour visits to Project site for this purpose, without additional cost.

END OF SECTION 260934

SECTION 260944**RELAY LIGHTING CONTROL SYSTEM****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes factory assembled lighting control (switching) relay panels, low-voltage wall control stations, control interface, and sensors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Lighting Control Devices" for general purpose occupancy sensors.
 - 2. Division 26 Section "Addressable Dimming Control System" for low-voltage, programmable lighting and dimming control system. Occupancy sensors associated with Addressable Dimming Control System are separate and distinct from the general purpose occupancy sensors specified in this section.
 - 3. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS

- A. Product Data: For each type of lighting control panel, relay, control station, interface and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each lighting control panel and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Load schedule indicating actual connected load, load type, and voltage per circuit, circuits, and their respective control zones.
 - 2. Wiring Diagrams: Schematic of system wiring differentiating between power and control wiring.

- C. Maintenance Data: For lighting control system and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout", include the following:
 - 1. Manufacturer's written installation guidelines.
 - 2. Final system wiring diagrams, load schedules, and zone schedules.
 - 3. Copy of facility programming set points.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
 - 1. Ambient temperature: 0° to 40° C (32° to 104° F).
 - 2. Relative humidity: Maximum 90 percent, non-condensing.
 - 3. Lighting control system must be protected from dust during installation.

1.6 WARRANTY

- A. Special Warranty for Lighting Control System: Provide manufacturer's written warranty covering two-year parts and labor to repair and replace defective equipment from date of Final Acceptance.

1.7 COORDINATION

- A. Coordinate layout and installation of lighting control panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Lighting Control System:
 - a. Lutron Electronics, Inc.
 - b. Crestron Electronics, Inc.
 - c. Leviton Mfg. Co., Inc.

2.2 LIGHTING CONTROL PANELBOARDS

- A. Basis of Design: Lutron Softswitch128

- B. Mechanical:

1. Listed to UL 508 as industrial control equipment.
2. Delivered and installed as a UL listed factory assembled panel.
3. Field wiring accessible from front of panel without need to remove dimmer assemblies or other components.
4. Panels passively cooled via free-convection, unaided by fans or other means.
5. Ship panels with each relay in mechanical bypass position by means of jumper bar inserted between input and load terminals. Jumpers to carry full rated load current and be reusable at any time. Mechanical bypass device to allow for switching operation of connected load with relay removed by means of source circuit breaker.
6. Surface mounted.

- C. Electrical:

1. Relays; meet following performance requirements:
 - a. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.
 - b. Rated life of relay: Minimum 1,000,000 cycles.
 - c. Load switched in manner that prevents arcing at mechanical contacts when power is applied to load circuits.
 - d. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
2. Minimum UL listed Short Circuit Current Rating (SCCR) per schedules on plans.

- D. LCD Panel Processor

1. System to be password protected.
2. Programming and system operation:
 - a. Control stations, control interfaces, and contact closure inputs
 - 1) Assign functionality of each control station button or infrared interface
 - a) Select patterns
 - b) Select customized pattern
 - c) Enable/Disable time clock
 - d) Initiate delay to off

- e) Toggle one, some, or all zones
 - 2) RS232 interface or Ethernet interface
 - 3) Contact closure output: Momentary or maintained
- b. Time clock
 - 1) Integral astronomical time clock
 - a) Geographic location (city or latitude/longitude).
 - b) Adjustable date and time format.
 - c) Adjustable starting and ending of daylight savings time.
 - d) Review and modify time clock schedule to add, copy, modify, and delete events.
 - e) Up to 500 time clock events
- c. Overrides:
 - 1) Set circuit status
 - 2) Select pattern
 - 3) Time clock override
 - 4) Control station overrides
 - 5) After-hours override
- 3. Integral contact closure inputs.
- 4. Networkable: Up to 8 relay panels can be networked together to form a complete interoperable system. Any relay on the system can be controlled by any input to the system regardless of physical location. Any relay can be programmed from any panelboard control pad.

E. Diagnostics and Service:

- 1. Replacing relay does not require re-programming of system or processor.
- 2. Relays: Include diagnostic LED's to verify proper operation and assist in system troubleshooting.
- 3. Relay panels: Include tiered control scheme for dealing with component failure that minimizes loss of control for occupant.
 - a. If lighting control system fails, lights to remain at current level. Panel processor provides local control of lights until system is repaired.
 - b. If panel processor fails, lights to remain at current level. Circuit breakers can be used to turn lights off or to full light output, allowing non-dim control of lights until panel processor is repaired.
 - c. If relay fails, factory-installed mechanical bypass jumpers to allow each relay to be mechanically bypassed. Mechanical bypass device to allow for switching operation of connected load with relay removed by means of circuit breaker.

2.3 CONTROLS & INTERFACES

- A. Override Switches: Low-voltage single button switch with LED pilot light. Provide engraved, color filled faceplate indicated "LIGHTING CONTROL OVERRIDE". Basis of Design: Lutron #FOMX-1B.
- B. Single Scene & Off Control Station: Low-voltage two button switch with LED pilot lights for all scenes with single dedicated contact closure input.
 - 1. Provide custom engraved buttons as follows:

- a. Button 1: "ON"
 - b. Button 2: "OFF"
 2. Basis of Design: Lutron #SO-2BON-WH with custom button engraving.
- C. 4-Scene & Off Control Station: Low-voltage five button switch with LED pilot lights for all scenes with single dedicated contact closure input.
1. Provide custom engraved buttons as follows: Engraving to be determined during shop drawing review process.
 - a. Button 1: "xxxxxx"
 - b. Button 2: "xxxxxx"
 - c. Button 3: "xxxxxx"
 - d. Button 4: "xxxxxx"
 - e. Off: "OFF"
 2. Basis of Design: Lutron #SO-4NRLON-WH with custom button engraving.
- D. Contact Closure Interface: Control shall provide two way interface between controls and dry contact closure devices such as from Timeclock Inputs, Building Management Systems, Fire Alarm Systems, Security Systems, and Occupancy Sensors. Control shall provide a minimum of five input and five output terminals. Input terminals must be able to accept maintained or momentary inputs with a minimum pulse time of 40msec. Inputs must have an on-state saturation voltage less than 2.0VDC and an off-state leakage current less than 10mA. Outputs must be capable of controlling other manufacturers' equipment. Customer provided output indicators must not exceed 200mA at 30VDC. Following functions shall be available and shall be set up in software: scene selection, panic mode, occupancy response, sequencing, zone and scene lockouts, and partitioning.
1. Provide a 5-input/5-output contact closure interface at each control panel
- E. Emergency Lighting Interface: Provides total system listing to UL924. The emergency lighting interface shall sense the normal (non-essential) line voltage on all three phases (3PH) of normal power. When one or more phases of power are lost, the interface shall send a signal to the emergency lighting relay panel controller, causing it to enter the emergency lighting mode. All relays in the emergency lighting control panel shall close bringing all emergency lighting circuit on. When normal power is restored the lights will return to their previous status. Interface shall also accept a contact closure input from a fire alarm control panel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting control panels and accessories according to NEMA PB 1.1.
- B. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.
- C. Mounting: Plumb and rigid without distortion of box. Mount recessed panel with fronts uniformly flush with wall finish.

- D. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Cross reference all room numbers to actual installed room signage. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- E. Install filler plates in unused spaces.
- F. Wiring in Panel Gutters: Arrange conductors into groups and bundle and wrap with wire ties.

3.2 CONTROL SYSTEM CONFIGURATION

- A. Automatic Time of Day Settings
 - 1. Interior Lighting Circuits
 - a. Schedule Monday through Sunday automatic 'ON' at 6:00am and automatic 'OFF' at 3-hrs after sunset.
 - 2. Exterior Lighting Circuits
 - a. Schedule Monday through Sunday automatic 'ON' at 1-hr prior to sunset and automatic 'OFF' at 3-hrs after sunset.
 - 3. Finalize schedules with Owner prior to Substantial Completion.
- B. Set impending 'OFF' warning duration at (5) five minutes.
- C. Override control switch settings (all interior switches)
 - 1. When lighting is schedule 'ON' – override switches shall be programmed such that pressing override button initiates timed override of impending scheduled 'OFF' events. Pressing override a second time restarts timed override.
 - 2. When lighting is scheduled 'OFF' – override switches shall be programmed such that pressing the button once initiates timed override of current scheduled 'OFF' event. Pressing the button a second time shall initiate an impending 'OFF' event with flash warning.
 - 3. Length of override timer shall be set at 60 minutes.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section "Conductors and Cables" for low-voltage connections and Division 26 Section "Voice and Data Systems" for digital circuits.
- B. Bundle, train, and support wiring in enclosures.
- C. Ground equipment.
- D. Connections: 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.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification".
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.5 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

- A. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.7 CLEANING

- A. On completion of installation, inspect interior and exterior of panels. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 260944

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SECTION 262416**PANELBOARDS****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. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- C. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Panelboard Schedules: For installation in panelboards. Room names and numbers shall match the final signage at the site. Submit final versions prior to installation in panelboard.
- E. Operation and Maintenance Data: For panelboards and 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. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.8 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Enclosures: Flush- and surface-mounted cabinets as noted on schedules.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 2. Front Cover: For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - a. Flush Mounted Panelboards: Standard front cover. Secured to box with concealed trim clamps. Trim shall extend beyond box at least 1" in all dimensions.
 - b. Surface Mounted Panelboards: Entire front trim hinged to box. Continuous piano hinge. Provide standard door with front trim.
 - 3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 4. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - 5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

- 6. Main Overcurrent Protective Devices: Molded-case circuit breakers.
 - a. Center Mounted Main: Branch mounted main breakers are not allowed.
- 7. Branch Overcurrent Protective Devices: Molded-case circuit breakers.
 - a. Center mounted branch devices and sub-feed branch devices are not allowed.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity
 - 1. Neutral Bus: Neutral bus rated 100 percent of phase bus.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box. For branch circuit panelboards provide a minimum of 21 terminals.
- D. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.
- E. Feed-through Lugs: Not acceptable.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices. Future devices indicated as "SPACE" on drawings.
- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rating of equipment is not acceptable.

2.3 DISTRIBUTION PANELBOARDS

- A. Panelboards: NEMA PB 1, power and feeder distribution type.
- B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches high, provide two latches, keyed alike.
- C. Mains: Circuit breaker.
- D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Mains: Circuit breaker, unless otherwise noted on drawings.

- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with full interrupting capacity to meet available fault currents.
 - 1. Electronic Trip Circuit Breakers: Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replicable electronic trip and individually field-adjustable long time, short time, and instantaneous trip pickup level settings. Trip unit shall also have adjustable long time and short time delay settings. Provide for circuit-breaker frame sizes 250A and larger.
 - a. Ground Fault Protection: Any circuit breaker serving as the service entrance overcurrent protective device for a structure shall have ground fault pickup and time delay settings in addition to overcurrent trip settings indicated above.
 - 2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Field adjustable instantaneous trip setting for circuit-breaker frame sizes 100 A to 225A.
 - 3. Breakers Serving Elevator Controllers: Field adjustable instantaneous-trip setting for circuit-breaker.
 - 4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Shunt Trip: Trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage. Match coil voltage to control power source.
 - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - h. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.6 INSTRUMENTATION

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Communications: Meter shall have a communications/network interface module, which enables the meter to communicate to the building automation system (BAS) via RS-485 Modbus protocol and a network management system via Owner's network infrastructure. The interface module shall include internal hardware and software to communicate (via SNMP and HTTP) to any I.P.-based Ethernet network through a RJ-45 connector. The module shall have redundant paths for communications that make it possible to connect to the BAS using Modbus while simultaneously communicating to through SNMP and HTTP. A terminal block shall be provided to connect to Modbus.
 3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install filler plates in unused spaces.
- F. Stub eight 3/4-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 3/4-inch empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- H. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Testing Technician

- a. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

2. Physical inspection and Testing

- a. Verify equipment rating correspond to drawings and specifications.
- b. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
- c. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
- d. Verify that all packing materials have been removed and the equipment has been cleaned.
- e. Confirm all breaker sizes, quantities, and configurations correspond to the drawings and specifications.
- f. Confirm bolted and mechanical lug electrical connections are low impedance using one of the following means:
 - 1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
 - 2) Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

3. Electrical Inspection and Testing

- a. Test each bus section for insulation resistance for one minute on phase to phase and phase to ground connections. Verify the test results comply with manufacturer's documentation or the requirements established in Table 100.1 of the ANSI/NETA ATS-2009.
- b. Verify all meters functionality and accuracy after testing and calibrating all inputs.
- c. Verify instrument transformers meet all the requirements of the drawings and specifications.
 - 1) Test transformer wiring integrity and proper transformer operation.
 - 2) Verify transformer output voltage is at the specified level.

4. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. Set field-adjustable circuit-breaker trip ranges. Unless otherwise noted, trip settings shall mimic trip characteristics for thermal magnetic circuit-breakers of similar trip rating.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 262416

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SECTION 262726**WIRING DEVICES****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. This Section includes receptacles, connectors, floor boxes, switches, wall-box dimmers, and finish plates.
- B. Related Sections include the following:
 - 1. Division 26 Section "Lighting Control Devices" for general purpose occupancy sensors.
 - 2. Division 26 Section "Relay Lighting Control Systems" for low-voltage, programmable relay based lighting control systems and associated wall stations.
 - 3. Division 26 Section "Addressable Dimming Lighting Control System" for low-voltage wall stations, occupancy sensors, and photocells associated with classroom dimming system.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- C. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Wiring Devices:
 - a. Hubbell, Inc.; Wiring Devices Div.
 - b. Leviton Manufacturing Co., Inc.
 - c. Pass & Seymour/Legrand; Wiring Devices Div.
 - 2. Floor Boxes:
 - a. Hubbell, Inc.; Wiring Devices Div.
 - b. Wiremold/Legrand.
 - c. Thomas & Betts Corporation.

2.2 STRAIGHT BLADE RECEPTACLES

- A. General Purpose Receptacles: Heavy-Duty grade, rated 20A minimum. Comply with UL498.
 - 1. NEMA 5-20R (standard #WD1.101968).
 - 2. Arranged for back and side wiring.
 - 3. Grounding type. Separate single or double grounding terminals with screw lugs and a direct, green insulated conductor connector to system ground. Screw shall be green and hex-headed. Self-grounding type are not acceptable.
 - 4. Weather-resistant receptacles shall be marked with WR on face.

5. Listed by an approved third party agency.
- B. GFCI Receptacles: Non feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle arranged to protect connected downstream receptacles on same circuit. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter. Comply with UL 498 and UL 943, Class A.
- C. USB Receptacles: Tamper-resistant duplex receptacle with USB charging capabilities, Heavy duty grade, rated 20A minimum. Comply with UL 498 and UL 1310, Fed Spec WC596.
 1. NEMA 5-20R (standard #WD1.101968).
 2. Arranged for back and side wiring.
 3. Grounding type. Separate single or double grounding terminals with screw lugs and a direct, green insulated conductor connector to system ground. Screw shall be green and hex-headed. Self-grounding type is not acceptable.
 4. Listed by an approved third party agency.
 5. Two 5-volt DC USB ports compatible with USB 2.0 & 3.0 devices. Ports shall provide 3.1A USB of charging capability.
 6. Design units for installation in a 2-3/4-inch deep outlet box without an adapter.
 7. Residential grade is not acceptable.

2.3 TWIST-LOCKING RECEPTACLES

- A. Single Receptacles: Heavy-duty grade. Comply with NEMA WD 1, NEMA WD 6 for configuration as required, or as shown on plans, and UL 498.

2.4 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.5 SWITCHES

- A. General Purpose Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
 1. 20A, 120/277v, AC only.
 2. Grounding type, with green hex-head grounding screw.
 3. Quiet type operating mechanism; shall not utilize mercury switches.
 4. Listed by an approved third party agency.

- B. Equipment Disconnect Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
 - 1. 30A, 120/277v, AC only.
 - 2. Grounding type, with green hex-head grounding screw.
 - 3. Quiet type operating mechanism; shall not utilize mercury switches.
 - 4. Listed by an approved third party agency.

2.6 WALL-BOX DIMMERS

- A. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

2.7 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.04-inch (1-mm) thick, Type 302, satin-finished stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
- B. Wet-Location, Weatherproof Cover Plates: "In Use" heavy cast aluminum with spring-loaded lift cover capable of closing with plug assembly still engaged, and listed and labeled for use in "wet locations".
 - 1. Body: 1/8-inch Cast Aluminum
 - 2. Springs: Stainless Steel
 - 3. Hinges: Plated Steel Pins
 - 4. Screws: Steel, Zinc-Plated or Aluminum
 - 5. Gasket: Neoprene
 - 6. Enclosure: Flush
 - 7. Cover: Lockable with cam lock and provided with two keys for entry
 - 8. Mortar keys to provide holding means within wall.

2.8 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from telecom cabling.
- C. Service Plate: Round, die-cast aluminum with satin finish.

- D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
- E. Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable complying with requirements in Section 267500 "Telecommunication Cabling Infrastructure."

2.9 FINISHES

- A. Color:
 - 1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Mount vertically except where installed over counters, back-splashes, etc. mount horizontally.
2. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Damp and Wet Locations:

1. Provide weather-resistant receptacles with weatherproof cover in damp and wet locations.
2. Provide additional weather-resistant receptacles with weatherproof cover as indicated on the plans.

G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

1. Provide 2% quantity of spare cover plates of each type to Owner.

H. Dimmers:

1. Install dimmers within terms of their listing.
2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

I. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Replace damaged or defective components.

3.4 CLEANING

- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 262726

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SECTION 262816**ENCLOSED SWITCHES AND CIRCUIT BREAKERS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
 - 1. Feeder and branch-circuit protection.
 - 2. Motor and equipment disconnecting means.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
- C. Field quality-control reports.

1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- D. Operation and Maintenance Data: For enclosed switches and circuit breakers 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. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Fusible Switches:
 - a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D Co.
 2. Molded-Case Circuit Breakers:
 - a. Eaton Corp.; Cutler-Hammer Products.
 - b. General Electric Co.; Electrical Distribution & Control Division.

- c. Siemens Energy & Automation, Inc.
- d. Square D Co.

2.2 ENCLOSED SWITCHES

- A. All Switches:
 - 1. Heavy Duty type with non-teasible, positive, quick make-quick break mechanisms.
 - 2. Handles whose positions are easily recognizable and are padlockable in either the "on" or "off" positions.
 - 3. Defeatable door interlocks that prevent the door from opening when the operating handle is in the "on" position.
- B. Enclosed, Non-fusible Switch: NEMA KS 1, Type HD, with lockable handle.
- C. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks.
 - 1. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- B. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Field-adjustable magnetic instantaneous trip setting for circuit-breaker frame sizes 250 A and larger.
 - 1. Breakers Serving Transfer Switches: Type and Frame size as required to meet "Specific Coordinated Molded Case Breaker" as required by automatic transfer switch for a minimum 42,000 A withstand rating.
 - 2. Breakers Serving Elevator Controllers: Field adjustable instantaneous-trip setting for circuit-breaker.
- C. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

2.4 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 4X.
 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
- B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
3. Verify equipment is properly secured and aligned as specified in the drawings and specifications.
4. Verify the equipment is clean.
5. Open and close circuit breaker to verify smooth and proper operation.
6. Confirm bolted electrical connections are low impedance using one of the following means:
 - a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
 - b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

D. Electrical Inspection and Testing

1. Test the insulation resistance on each pole. The resistance should be measured from phase to phase and phase to ground while the breaker is engaged. When the switch is not engaged the insulation resistance should be measured across each pole. For testing purposes apply a voltage as recommended by the manufacturer. If no recommendations are available from the manufacturer refer to Table 100.1 in the ANSI/NETA ATS-2009.

E. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Remove and replace units that do not pass tests and inspections and retest as specified above.

H. Retain paragraph below if tests and inspections are performed by Contractor or manufacturer's field-service representative engaged by Contractor.

I. 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.

END OF SECTION 262816

SECTION 263323**CENTRALIZED EMERGENCY LIGHTING INVERTER****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. This Section includes uninterruptible power supply type centralized emergency lighting inverters with a microprocessor controlled pulse-width-modulated (PWM) inverter, high speed transfer devices, constant voltage regulating transformer, battery charging system, batteries, and integral monitoring display panel.
- B. Related Sections:
 - 1. Division 26 Section "Seismic Controls for Electrical Systems" for seismic restraint performance requirements including Site Classification and Seismic Use Group.

1.3 DEFINITIONS

- A. THD: Total harmonic distortion.
- B. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

- A. Product Data: For all inverter system components, including, but not limited to UPS, battery charger, and batteries.
- B. Seismic Controls:
 - 1. Delegated-Design Submittal: For each seismic-restraint device, include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly drawings of supports.
 - b. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.
 - 2. Seismic Qualification Certificates: For emergency lighting equipment, accessories, and components, from manufacturer.

- a. Certificate of compliance.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - 1. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
 - 2. Elevation and details of control and indication displays.
 - 3. Output distribution section.
- D. Manufacturer Certificates: For each product, from manufacturer.
- E. Field quality-control test reports.
- F. Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.
- G. Operation and Maintenance Data: For central battery inverter equipment to include in emergency, operation, and maintenance manuals.
- H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Central Battery Inverter System: UL 924 listed.
- C. Comply with NFPA 70, NFPA 101, and NFPA 111.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment in fully enclosed vehicles.
- B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
 - 1. Warranty Period for Sealed Valve-Regulated, Lead-Calcium Batteries:
 - a. Full Warranty: One year.
 - b. Pro Rata: Nine years following one year of full warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Myers Power Products, Inc. (Basis of Design)
 - 2. Controlled Power Company.
 - 3. Chloride Systems.
 - 4. Crucial Power Products.

2.2 INVERTER PERFORMANCE REQUIREMENTS

- A. Uninterruptible Power Supply (UPS) Type Emergency Lighting Inverters: Continuously provide ac power to connected electrical system.
 - 1. Automatic Operation includes the following:
 - a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier-charger and inverter, with battery connected in parallel with rectifier-charger output.
 - b. Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
 - c. If normal power fails, battery continues supply-regulated ac power through the inverter to the load without interruption of power or any disturbance.
 - d. When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier-charger then supplies power to the load through the inverter and simultaneously recharges battery.
 - e. If battery becomes discharged and normal supply is available, rectifier-charger charges battery. When battery is fully charged, rectifier-charger automatically shifts to float-charge mode.

- f. If any element of central battery inverter system fails and power is available at normal supply terminals of system, static bypass transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
 - g. If a fault occurs in system supplied by central battery inverter and current flows in excess of the overload rating of central battery inverter system, static bypass transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
 - h. When fault has cleared, static bypass transfer switch returns the load to central battery inverter system.
 - i. If battery is disconnected, central battery inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.
- B. Output Load Capacity: Rated in KVA at 1.0 (unity) power factor. Refer to plans for size.
- C. Overload Capability: 125% for ten minutes.
- D. Surge Capability: 150% of rated output without need of static bypass.
- E. Frequency Stability: ± 0.2 Hz.
- F. Efficiency: Not less than 89% under full rated load.
- G. Maximum Acoustical Noise: 50dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches from nearest surface of component enclosure.

2.3 SERVICE CONDITIONS

- A. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Ambient Temperature for Electronic Components: 32 to 105 deg F.
 - 2. Relative Humidity: 0 to 95 percent, noncondensing.
 - 3. Altitude: Sea level to 4000 feet.
- B. Physical Limitations: Centralized emergency lighting inverter is shown on plans for installation in restricted/limited space. Maximum dimensions of equipment, including both UPS and battery cabinets where separate, are the following:
 - 1. Maximum width: 48" wide.
 - 2. Maximum depth: 24" deep.

2.4 INVERTERS

- A. Description: Solid-state pulse-width-modulated (PWM) type, with the following operational features:
1. AC Input:
 - a. Input Voltage: 208 VAC, single-phase, two-wire plus ground.
 - b. Input Voltage Operating Range: +10% to -15%.
 - c. Frequency: 60 Hz, ± 3 Hz.
 - d. Surge Protection: Compliant with ANSI C62.41 (IEEE 587).
 - e. Provide integral main circuit breaker protection on AC input.
 2. AC Output
 - a. Output Voltage: 120 VAC, single-phase, two-wire plus ground.
 - b. Output Voltage Regulation: $\pm 3\%$.
 - c. Output Harmonic Distortion: Less than 5% under linear load, Less than 10% total under all listed loads.
 - d. Frequency Regulation: ± 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
 - e. Provide integral main output circuit breaker and, unless otherwise noted on schedules, provide a minimum of eight (8) 20A/1P branch output circuit breakers.
 3. Output Protection: Current-limiting and short-circuit protection.

2.5 BATTERY CHARGER

- A. Description: Solid-state full wave, three-stage, filtered, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes. Recharge time UL 924, NFPA 101, and NFPA 111 compliant.

2.6 BATTERIES

- A. Description: Integral, valve-regulated, sealed, maintenance free lead calcium batteries.
1. Operating Time: Minimum 90 minutes at full rated kilowatt output capability, UL 924 Compliant.
 2. Battery Cell Voltages: 2.27 V per cell float, 1.75 V per cell final.
 3. Battery Life: Expected service life of 10 years.

2.7 ENCLOSURES

- A. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.

- B. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.
- C. Input and Output Breakers shall be mounted through door or behind a dead-front cover such that they are operable without exposing user to live conductors.

2.8 CONTROL AND INDICATION

- A. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.
- B. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.
- C. Indications: Plain-language messages on a digital LCD.
 - 1. Quantitative Indications:
 - a. Input voltage, each phase, line to line.
 - b. Input current, each phase, line to line.
 - c. System output voltage, each phase, line to line.
 - d. System output current, each phase.
 - e. System output frequency.
 - f. DC bus voltage.
 - g. Battery current and direction (charge/discharge).
 - h. Elapsed time-discharging battery.
 - 2. Basic Status Condition Indications:
 - a. Normal operation.
 - b. Load-on bypass.
 - c. Load-on battery.
 - d. Inverter off.
 - e. Alarm condition exists.
 - 3. Alarm Indications:
 - a. Battery system alarm.
 - b. Control power failure.
 - c. Fan failure.
 - d. Overload.
 - e. Battery-charging control faulty.
 - f. Input overvoltage or undervoltage.
 - g. Approaching end of battery operation.
 - h. Battery undervoltage shutdown.
 - i. Inverter fuse blown.
 - j. Inverter transformer overtemperature.
 - k. Inverter overtemperature.
 - l. Static bypass transfer switch overtemperature.

- m. Inverter power supply fault.
 - n. Inverter output overvoltage or undervoltage.
 - o. System overload shutdown.
 - p. Inverter output contactor open.
 - q. Inverter current limit.
- 4. Controls:
 - a. Inverter on-off.
 - b. Start.
 - c. Battery test.
 - d. Alarm silence/reset.
 - e. Output-voltage adjustment.
- D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
 - 1. Inverter on battery.
 - 2. Inverter on-line.
 - 3. Inverter load-on bypass.
 - 4. Inverter in alarm condition.
 - 5. Inverter off (maintenance bypass closed).

2.9 MAINTENANCE BYPASS

- A. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:
 - 1. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal ac input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
 - 2. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 - 3. Normal: Normal central battery inverter ac supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.

2.10 SYSTEM MONITORING AND ALARMS

- A. Remote Status and Alarm Panel: Labeled LEDs on panel faceplate shall indicate basic status conditions of normal power, battery power, low-battery, fault/alarm. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
 - 1. Cabinet and Faceplate: Flush mounted to suit mounting conditions indicated.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install system components on concrete base and attach by bolting.
 - 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 3 inches in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Basic Electrical Materials and Methods."
 - 2. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 4. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

- A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

3.4 IDENTIFICATION

- A. Identify equipment and components according to Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Technician

- 1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

- B. Physical Inspection and Testing

- 1. Verify equipment rating correspond to drawings and specifications.
 - 2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
 - 3. Verify equipment is properly secured and aligned and grounded as specified in the drawings and specifications.
 - 4. Verify the equipment is clean.
 - 5. Confirm bolted electrical connections are low impedance using one of the following means:
 - a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
 - b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

- C. Electrical Inspection and Tests

- 1. Test the equipment's transferring capabilities for correct operation.
 - 2. Verify controls function according to manufacturer's standards and verify that any alarms trigger properly. Test the synchronization indicators for static and bypass switches.

- D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

- E. Tests and Inspections:

- 1. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.

2. Test manual and automatic operational features and system protective and alarm functions.
 3. Test communication of status and alarms to remote monitoring equipment.
- F. Remove and replace malfunctioning units and retest as specified above.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Verify that central battery inverter is installed and connected according to the Contract Documents.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.7 CLEANING

- A. On completion of installation, inspect interior and exterior of cabinets. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- B. Install new filters in each equipment cabinet within 14 days from date of Substantial Completion.

3.8 DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain emergency lighting inverters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 263323

SECTION 265100**LIGHTING****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. Lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

- B. Emergency Lighting Equipment, including supporting raceway, requires Seismic Controls. Equipment is required to be certified by the manufacturer. Engineer has delegated design of controls for mounting and supports to Contractor.

1. Delegated Design: Design emergency lighting equipment supports, mounting, and associated raceway supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Emergency lighting equipment shall withstand the effects of earthquake motions determined according to ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".
3. Structural Performance: Emergency lighting equipment supports, mounting, and associated raceway supports shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE 7.
 - a. Seismic Loads: Refer to Specification Section 260548.

- C. Related Sections:

1. Division 26 Section "Lighting Control Devices" for occupancy sensors, contactors, and emergency lighting transfer devices.
2. Division 26 Section "Addressable Dimming Control System" for modular classroom dimming systems.

3. Division 26 Section "Relay Lighting Control System" for programmable relay control systems with low-voltage control wiring.
4. Division 26 Section "Seismic Controls for Electrical Systems" for seismic restraint performance requirements including Site Classification and Seismic Use Group.

1.3 STANDARDS

- A. The standards and regulating committees referred in this specification and to which compliance with is required are:
 1. UL Underwriters Laboratories
 2. NRTL Nationally Recognized Testing Laboratory
 3. NEC National Electric Code
 4. ANSI American National Standards Institute
 5. ASTM American Society of Testing and Materials
 6. NEMA National Electrical Manufacturers Association
 7. IEC International Electrotechnical Commission
- B. All fixtures and assembled components shall be new, of good quality, and be approved by and bear the label of UL for the applicable location and conditions (wet, damp, dry, etc.) or other approved testing agencies, i.e. CSA, ETL.
 1. Label shall not interfere with fixture performance, maintenance, or the seating of any fixture element, and shall not be visible during normal fixture operation.
- C. All fixtures shall meet all required local, state and/or national building, electrical and energy codes and regulations.

1.4 SUBMITTALS

- A. Product Data:
 1. Fixture Schedule Matrix: At the front of the product data submittal provide a matrix that lists the fixture manufacturer and model number, ballast manufacturer and model number, lamp manufacturer and model number for each fixture type in schedule.
 2. Light Fixtures: For each type of lighting fixture in schedule, arranged in order of fixture designation. Provide manufacturer's published literature which includes data on features, accessories, and the following:
 - a. Dimensions of fixtures.
 - b. Manufacturer and type of ballasts.
 - c. Manufacturer and types of lamps.
 - d. For fixtures (non-exit) with LED light source submit the manufacturer's IESNA LM-79 Photometric Report and IESNA LM-80 Lumen Maintenance Report.
 - e. Method of emergency ballast installation (integral, external, or remote).
- B. Seismic Controls:

1. Delegated-Design Submittal: For each seismic-restraint device, include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly drawings of supports.
 - b. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.
 2. Seismic Qualification Certificates: For emergency lighting equipment, accessories, and components, from manufacturer.
 - a. Certificate of compliance.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Shop Drawings:
1. Site Lighting Illumination Plan: Provide computer generated iso-footcandle plot diagrams for both initial and maintained footcandles on all horizontal patio, landing, walkway, roadway, and parking surfaces which show composite values of illuminance projected from the arrangement of all building mounted and non-building mounted light fixtures. Use manufacturer's published maintenance factors in calculating maintained footcandles. Calculation grid shall be 2' x 2' on pedestrian surfaces and 5' x 5' on vehicular surfaces. Also provide spill light iso-footcandle plot diagrams for both horizontal and vertical maintained footcandles along property/LEED boundary and 10' beyond property/LEED boundary. Calculation grid shall be 10' on center along boundary. Plans depicting building mounted lighting and egress pedestrian surfaces shall be scaled no greater than 1"=10'. Plans depicting vehicular surfaces and property boundary shall be scaled no greater than 1"=30'.
- D. Warranty Information: Include in submittals warranty information for emergency exit signs, emergency lighting units, and emergency ballasts installed in schedule fixtures.
- E. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.
- F. Test Reports: Report of operation test for emergency lighting units, emergency ballasts, and battery-powered exit signs. See Field Quality Control paragraph below. Submit copy to State Construction Office.
- G. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 1. Provide revised and updated Fixture Schedule Matrix. Include all warranty information and documentation with maintenance data.

1.5 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.6 COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.7 WARRANTY

- A. All fixtures and workmanship shall be guaranteed free of defects and fully operational for a minimum of one year after the acceptance of the project by the Owner. Any fixtures or workmanship found to be defective during the warranty period will be either fixed or replaced by the Contractor at no cost to the Owner.
- B. Special Warranty for Emergency Exit Signs, Emergency Lighting Units, and Emergency Ballasts: Written warranty, executed by manufacturer agreeing to replace entire sign/unit/ballast that fails within 3 years from date of Final Acceptance. The batteries within sign/unit/ballast shall be covered for an additional 2 years by a pro-rated warranty.

1.8 EXTRA MATERIALS

- A. Furnish to the owner and store at the site where directed, extra stock of each type of lighting fixture driver installed in the Project in quantities as required by Owner, packaged in manufacturer's unopened cartoons and identified as to contents by fixture type.
- B. Furnish items above with appropriate quantity of each exposed trim, fastener, bracket and other items as required for a complete installation.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Available Manufacturers and Products: Subject to compliance with requirements, manufacturers and respective products that may be incorporated into the Work are indicated on the drawings in Light Fixture Schedule.

1. It is the intent of the Light Fixture Schedule to denote the Basis of Design and quality standard of product desired and not to restrict bidders to a specific brand, make, manufacturer or specific name. The manufacturers and products listed in Schedule are used only to set forth and convey to bidders the general style, type, character, and quality of product desired. However, the use of products by a manufacturer not listed in Schedule is considered a substitution. Substitution of equivalent products will be acceptable according to the following paragraph.
- B. Substitution of Equivalent Products: Substitution of manufacturers and products equivalent to those listed in Light Fixture Schedule shall be submitted to the Engineer for approval more than 10 days prior to Bid Date. Submittal shall include all items listed in Article 1.4A and an IES photometric report file specific to the fixture configuration being submitted. Engineer has final authority on equivalence and acceptance.
- C. Equivalent fixtures, poles, ballasts, and other materials and equipment shall be products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall be a standard product offering as shown on manufacturer's published printed literature for appearance, mounting, light distribution and lamping (ballast and lens options are excluded from this requirement). Cut-sheets prepared for submittal are not considered published printed literature. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same type or class of fixture are required, these items shall be products of a single manufacturer.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Fixtures shall be free of light leaks and shall be designed to provide sufficient ventilation of lamps and ballasts including vent holes where required.
- B. Outdoor fixtures shall have wire mesh corrosion resistant screens in the vent holes properly sized to prevent incursion of insects, small animals, and/or other small rodents.
- C. In outdoor applications, and where the ambient falls below 50°F, all lamps and ballasts shall be rated for operation at 0°F.
- D. In adjustable fixtures, aiming and positive locking devices shall be provided.
- E. Fixtures with an adjustable lamp and using a lamp with an asymmetrical light pattern shall have an aiming stop which can be permanently set so that the lamp shall remain correctly positioned after service or relamping.
- F. Metal Parts: Free from burrs, sharp corners, and edges.
- G. Sheet Metal Components: Steel, unless otherwise indicated.

1. Form work shall be properly fabricated so that planes will not deform (i.e. become concave or convex, due to normal expected ambient and operating conditions).
 2. Free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal.
 3. Intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.
 4. Miters shall be in accurate alignment with abutting intersecting members.
 5. Piecing of plates in individual runs in single planes and the use of spliced pieces or filler material to cover defective workmanship shall not be acceptable.
- H. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- I. Fasteners: Manufactured of non-magnetic stainless steel or anodized aluminum, except in indoor applications where galvanized steel shall be acceptable.
- J. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
 4. Laminated Silver Metallized Film: 90 percent.
- K. Lenses:
1. Glass:
 - a. Flat glass lenses shall be heat tempered borosilicate glass unless otherwise noted.
 - b. Glass finishes, i.e. sandblasting, etching, polishing shall be performed as described in the fixture description.
 2. Acrylic:
 - a. Lenses shall be of injection molded crystal clear material 100% virgin acrylic (except as shown). For lenses with male pattern of pyramids or cones, specified minimum thickness refers to distance from flat surface to base of pyramids (cones), or thickness of undisturbed material. For lenses with female pattern, specified minimum thickness refers to overall thickness of material.
 - b. Lenses shall fully eliminate lamp images when viewed from all directions within the 45° to 90° angle from vertical when the ratio of lamp spacing to the distance from lamp underside to top of lens does not exceed 1.50. Within the viewing angle from 0° to 45° the ratio of maximum brightness (under a lamp) to minimum brightness (between lamps) shall not exceed 3 to 1.
 - c. Finishes, i.e. sandblasting, etching, polishing shall be performed as described in the fixture description.
- L. Louvers:

1. Parabolic:
 - a. Louvers shall be continuously bound in channel formed frame, finish and color as specified or as selected.
 - b. Louver shall provide a minimum visual cut-off to the lamp of 45°.
 - c. The finish of the inner surface of the reflector shall be highly specular as produced under the Alzak process. The reflector shall have an anodic coating of not less than four mils thick. The reflector inner surface shall be free of water spotting and shall maintain a reflectivity ratio of not less than 83% on clear specular finish. The reflector shall have a low iridescence finish free from multiple colors seen from normal viewing angles.
2. Flat Blade:
 - a. Provide flat blade louvers within formed frame, finish and color as specified.
 - b. Louvers to provide minimum of 45° degree cut-off from lamp image.
 - c. Blade thickness to minimum .125" flat steel.

M. Wiring:

1. Temperature Rating – Internal to Fixture
 - a. All wiring shall be code-approved for fixture wiring, and shall comply with the following temperature ratings unless fixture design or local codes require higher temperature wire.
2. Splices
 - a. Splices internal to fixture shall be made within separate splice compartments and shall utilize nylon insulated crimped connections or insulated quick disconnects.
 - b. Splices to branch circuit wiring in separate junction boxes shall utilize flame retardant thermoplastic caps with fully seated helical metal spring and threaded entry.
3. No internal wiring shall be visible at normal viewing angles, i.e., above 45° from vertical. Use additional wire clamps if necessary. Anticipate increased visibility if fixtures are mounted on or recessed within a sloping surface.
4. Any fixture fed from more than one panel, i.e., for normal and night or emergency operation, shall have separate neutrals to each panel.
5. Furnish code-approved wiring in ceiling cavities forming air plenums.

N. Pole/Luminaire Assemblies:

1. Supply luminaires, davit arms, brackets, poles, handhole covers, base components, and all other accessories complete by specified manufacturer who will be responsible for proper fitting of all elements.
2. Manufacturer will supply assembly to withstand 100 mph winds with a 1.3 gust factor without permanent deflection.
3. Manufacturer shall be responsible for design of and structural integrity of complete base (i.e., concrete dimensions, rebar requirements, grounding and conduit requirements, drainage and ground compaction requirements).
4. Luminaire poles shall be third party listed for the appropriate environmental conditions, including use as a raceway if applicable.

2.3 SOLID STATE LIGHTING – LED LUMINAIRES, DRIVERS, AND COMPONENTS**A. General:**

1. Luminaire manufacturer shall have a minimum of five (5) years' experience in the manufacture and design of LED products and systems and no less than one hundred (100) installations.
2. All LED luminaires and power/data supplies shall be provided by a single manufacturer to ensure compatibility.
3. All components, peripheral devices and control software are to be provided by and shall be the responsibility of a single entity. All components shall perform successfully as a complete system and shall operate as described in Light Fixture Schedule.
4. Include all components necessary for a complete installation. Provide all power supplies, synchronizers, data cables, and data terminators for a complete working system.
5. Compatibility of driver and LED light engine must be tested and ensured by driver manufacturer.
6. All LED sources used in the LED luminaire shall be of proven quality from established and reputable LED manufacturers and shall have been fabricated after 2007. Acceptable LED lamp manufacturers unless otherwise noted are:
 - a. Cree, Inc.
 - b. Philips Lighting
 - c. Nichia Corporation
 - d. Norlux
 - e. Opto Technology, Inc.
 - f. Osram Optronics Semiconductors

B. Replacement and Spares:

1. Manufacturer shall provide written guarantee of the following:
 - a. Manufacturer will keep record of original bin for each LED module and have replacement modules from the same bin available for three (3) years after date of installation.
 - b. Manufacturer will keep an inventory of replacement parts (source assembly, power and control components).
 - c. Manufacturer's LED system will not become obsolete for ten (10) years: Manufacturer will provide exact replacement parts, or provide upgraded parts that are designed to fit into the original luminaire and provide equivalent distribution and lumen output to the original, without any negative consequences.
2. All parts of system shall be replaceable in field. Manufacturer shall provide written guarantee of the following:
 - a. Manufacturer has in place a written recycling and re-use program, and will accept returned product and/or components for recycling or re-use.
 - b. Manufacturer will properly dispose of non-recyclable components that are deemed harmful to the environment.
 - c. System shall carry a full warranty for five (5) years. Manufacturer shall be responsible for cost of labor not to exceed \$50 per individual part, and cost of shipping, to replace any component of the system that fails within 2 years of installation.

3. Products and Components – Performance
 - a. LED luminaires and components shall be UL listed or UL classified.
 - b. LED luminaires and components shall be CE certified.
 - c. LED luminaires and components shall be PSE marked.
 - d. All LED luminaires shall be subjected to the following JEDEC Reliability Tests for Lead-free Semiconductors: HTOL, RTOL, LTOL, PTMCL, TMSK, Mechanical Shock, Variable Vibration Frequency, SHR, and Autoclave.
 - e. To ensure luminaire quality, luminaire shall have been tested under accelerated life test conditions including an operating temperature span of 360 degrees F, and cyclic loading up to 60G.
 - f. All products included in system shall use Mil-Std 810F, Random Vibration 7.698g as a minimum standard. In installations subject to vibration, luminaire shall be installed with vibration isolation hardware to sufficiently dampen vibrations.
 - g. All LED components shall be mercury and lead-free.
 - h. All manufacturing processes and materials shall conform to the requirements of the European Union's Restriction on the Use of Hazardous Substances in Electrical and Electronics Equipment (RoHS) Directive, 2002/95/EC.
 - i. LEDs shall comply with ANSI/NEMA/ANSI C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products. Color shall remain stable throughout the life of the lamp. Color shall match approved sample.
 - j. LEDs shall comply with IESNA LM-80 – Standards for Lumen Maintenance of LED Lighting Products.
 - k. White LEDs shall have a rated source life of 50,000 hours under normal operating conditions. RGB LEDs shall have a rated source life of 100,000 hours. LED “rated source life” is defined as the time when a minimum of 70% of initial lumen output remains.
 - l. Luminaire assembly shall include a method of dissipating heat so as to not degrade life of source, electronic equipment, or lenses. LED luminaire housing shall be designed to transfer heat from the LED board to the outside environment. Luminaire housing shall have no negative impact on life of components.
 - m. Manufacturer shall supply in writing a range of permissible operating temperatures in which system will perform optimally.
 - n. High power LED luminaires shall be thermally protected using one or more of the following thermal management techniques: metal core board, gap pad, and/or internal monitoring firmware.
 - o. LEDs shall be adequately protected from moisture or dust in interior applications.
 - p. For wet and damp use, LED-based luminaires itself shall be sealed, rated, and tested for appropriate environmental conditions, not accomplished by using an additional housing or enclosure. Such protection shall have no negative impact on rated life of source or components, or if so, such reductions shall be explicitly brought to the attention of the designer.
 - q. All hardwired connections to LED luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.

- r. The LED luminaire shall be operated at constant and carefully regulated current levels. LEDs shall not be overdriven beyond their specified nominal voltage and current.
- s. Manufacturer shall be able to provide supporting documentation of the product meeting third party regulatory compliance.
- t. Manufacturer shall ensure that products undergo and successfully meet appropriate design and manufacturability testing including Design FMEA, Process FMEA, Environmental Engineering Considerations and Laboratory Tests, IEC standards and UL/CE testing.
- u. All LED luminaires (100% of each lot) shall undergo a minimum twenty-four (24) hour burn-in during manufacturing, prior to shipping.
- v. Manufacturer shall provide Luminaire Efficacy (lm/W), total luminous flux (lumens), luminous intensity (candelas) chromaticity coordinates, CCT and CRI, optical performance, polar diagrams, and relevant luminance and illuminance photometric data. Provide data in IES file format in accordance with IES LM-79-2008, based on test results from an independent Nationally Recognized Testing Laboratory.
- w. Power / data supply shall have the following:
 - 1) Supply outputs shall have current limiting protection.
 - 2) Supply shall provide miswiring protection.
 - 3) Supply shall have power factor correction.
 - 4) Supply shall provide connections that are conduit-ready or clamp-style connections in the case of low-voltage wiring.
 - 5) Supply shall come with a housing that meets a minimum IP20 rating for dry location installation unless located in a damp or wet location.
 - 6) Supply shall be UL listed for Class 1 or Class 2 wiring
- 4. LED Control and Communication – Performance
 - a. LED luminaires shall be network controllable via digital control.
 - b. The LED system shall use integral and differential non-linear control.
 - c. Constant data transmission rates shall be employed, resulting in the output being independent of distance of cable between power supply and light source within the specified length.
 - d. LED system shall have a selectable means of external control via a data network.
 - e. Each LED luminaire and/or node shall have the capability to be set to a unique and individual address. Address shall be selectable through on board switches or by an external hardware or software method.
 - f. The LED system shall be scalable, with every LED luminaire/address in the system capable of being controlled by a single, centralized controller.

C. Driver:

- 1. Ten-year operational life while operating with a case temperature range of 0 degrees C to 62 degrees C and 90 percent non-condensing relative humidity.
- 2. Electrolytic capacitors to operate at least 20 degrees C below the capacitor's maximum temperature rating when the driver is under fully-loaded conditions and case temperature is 62 degrees C.
- 3. Designed and tested to withstand electrostatic discharges up to 15,000 V without impairment per IEC 801-2.
- 4. Maximum inrush current of 2 amperes for 120V and 277 V drivers.

5. Withstand up to a 4,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A.
 6. Manufactured in a facility that employ ESD reduction practices in compliance with ANSI/ESD S20.20.
 7. Inaudible in a 27 dBA ambient environment.
 8. No visible change in light output with a variation of +/- 10 percent line voltage input.
- D. Total Harmonic Distortion less than 10 percent and meet ANSI C82.11 maximum allowable THD requirements.

2.4 EMERGENCY EXIT SIGNS

- A. General Requirements: Comply with UL 924 and the following:
1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
 2. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life. Maximum LED failure rate shall be 25% within a 7 year period.
 3. Emergency Operation: When normal voltage drops below 80% nominal, sign shall switch to operation from emergency battery.
 4. Testing Features: Exit sign shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. Sign shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
 5. Exit Signs shall be third party listed as emergency lighting equipment, and meet or exceed the following standards: NEC, NC Building Code, NC Energy Conservation Code, NFPA 101, and any applicable NEMA standards.
- B. Integral Emergency Battery: Battery shall be sealed, maintenance-free nickel-cadmium sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with an operating range of 0°C to 60°C and contain a resealable pressure vent. Exterior signs shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.
- C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

2.5 EMERGENCY LIGHTING UNIT

- A. General Requirements: Comply with UL 924 and the following:
1. Description: Emergency lighting unit shall be a completely self-contained lighting unit designed to provide emergency illumination upon loss of normal power. Unit contains battery, automatic charger, transfer device, lamps, and testing features.
 2. Emergency Operation: When normal voltage drops below 80% nominal, unit shall activate to operate lamps from emergency battery. Lamps are off during normal operation.

3. Testing Features: Units shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. It shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
 4. Emergency Lighting Units shall be third party listed as emergency lighting equipment.
- B. Emergency Battery: Battery shall be 12V sealed, maintenance-free nickel-cadmium sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with an operating range of 0°C to 60°C and contain a resealable pressure vent. Exterior units shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.
- C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

2.6 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Supporting Devices", for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Refer to "Light Fixture Mounting Detail" on plans for individual fixture support.

2.7 FINISHES

- A. Fixtures: Manufacturers' standard, unless otherwise indicated.
1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.

PART 3 - EXECUTION

3.1 SHIPPING AND STORAGE

- A. All fixtures received at the site shall be stored in clean and dry space until fixtures are installed.
- B. Manufacturer shall clearly mark each box with fixture designation prior to shipping.
- C. Reflector cones, baffles, louvers, aperture plates, and decorative elements of fixtures shall be packaged by the manufacturer separate from the housing (body, stem, etc.) of the fixture.

3.2 LOCATION

- A. Locations of fixtures are shown diagrammatically. Verify exact location and spacing with Reflected Ceiling Plans and other reference data before ordering of fixtures and during installation.
- B. Notify Architect about field conditions at variance with Contract Documents before commencing installation.
- C. Coordinate space conditions with other trades before ordering of fixtures.
- D. Pendant mount, as approved, surface type fixtures where required to meet space conditions.

3.3 INSTALLATION

- A. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Fixture catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a fixture may be installed.
- B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.
- C. Install rows of fixtures accurately on straight lines unless otherwise noted on drawings. Coordinate with mechanical work.
- D. Install fixtures with vent holes free of air blocking obstacles.
- E. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.
 - 1. Fixtures within Ceiling Grid: Where a recessed fluorescent, high intensity, or downlight fixture replaces a section or part of a ceiling tile, the fixture shall be supported at the two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support the lay-in ceiling track. Attach one end of the wire to one corner of the luminaire and the other end to the main runners of the lay-in ceiling track at all four (4) corners using sheet metal screws. For fire rated suspended ceiling, luminaire shall be supported to the Building Structure as per the Ceiling Design Criteria, luminaire shall then be screwed to the main runners of the suspended ceiling track at all four (4) corners using sheet metal screws.
 - 2. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning between ceiling tees in addition to wires from building structure per above. Channel support shall be attached to ceiling grid using sheet metal screws.
 - 3. Contractor shall be responsible for verifying weight and mounting method of all fixtures and providing suitable supports. Fixture mounting assemblies shall comply with all local seismic codes and regulations.

- F. Contractor shall be responsible for adjusting aperture rings on all ceiling recessed fixtures to accommodate various ceiling material thickness. Contractor shall be responsible for coordinating the cut-out size in ceiling to ensure aperture covers cut-out entirely. The bottom of aperture rings shall be flush with finished ceiling or not more than 1/16" above. Under no circumstances will the aperture ring extend below the finished ceiling surface.
- G. For fixtures with variable position lampholder assemblies Contractor shall confirm prior to installation proper lampholder (socket) position in field, and shall adjust, if necessary, after coordination with manufacturer.
- H. Surface Mounted Fixtures: Support surface mounted fixtures from structural members other than ceiling tees.
- I. Pendant Mounted Fixtures:
 - 1. Pendant mounted fixtures shall be supported from structural framework of ceiling or from inserts cast into slab.
 - 2. All pendants shall have swivel aligners located at the top ends; pendants shall be 1/2" rigid steel conduit unless specifically indicated otherwise on drawings or in specifications.
 - 3. All fluorescent pendant and surface mounted fixtures shall be supported with two (2) supports per four foot section or three (3) per eight foot section.
- J. Bracket Mounted Fixtures: For each bracket fixture, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the fixture rigidly in design position. Flanged part of fixture stud shall be of broad base type, secured to outlet box at not fewer than three (3) points.
- K. Top Re-lamping Fixtures: Top re-lamping fixtures shall have the necessary top-re-lamping screws loosened and moderately tightened, prior to installation, to assure ease of operation when re-lamping is required.
- L. Mask the trims and bottoms of all lighting fixtures if necessary to protect the fixture during construction.
- M. Ensure that all lamps installed are exactly as specified for each fixture type.
- N. At the completion of construction clean the bottoms, the trim, the reflecting surfaces, lenses, baffles, louvers and reflector cones of all lighting fixtures so as to render them free of any material, substance or film foreign to the fixture. If the luminaires are deemed dirty by the Architect at the completion of the project, the Contractor shall clean them at no additional cost to the Owner. Luminaire components whose finishes are damaged shall be replaced at no cost to the Owner.
- O. Provide labor and materials for final aiming of all adjustable fixtures under the Architect's supervision. Aiming shall take place immediately before building is turned over to Owner, after regular working hours where required.

3.4 CONNECTIONS

- A. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Provide instruments to make and record test results.
- C. Tests: As follows:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - a. Contractor shall perform a test on each battery unit after it is permanently installed and charged for a minimum of 24 hours. Battery units shall be tested for 90 minutes and shall maintain not less than 60% of the initial emergency illumination or 87-1/2% of initial battery voltage for the duration of the test. Any unit which fails the test must be repaired or replaced, and tested again. Copy of testing report for each unit shall be sent to the Engineer.
 - b. All battery tests shall be complete a minimum of 10 days prior to final inspection.
 - 3. Verify operation of photoelectric controller and contactor.
 - 4. Verify normal transfer to battery source and retransfer to normal.
 - 5. Report results in writing.
- D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.
- E. Corrosive Fixtures: Replace during warranty period.

3.6 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION 265100

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SECTION 267413**AUDIOVISUAL SYSTEM****PART 1 - GENERAL****1.1 PROJECT OVERVIEW**

- A. New Hanover County (NHC) is constructing Pine Valley Branch Library at Fulton Station in Wilmington, North Carolina. The building shall be provided with media-enhanced instruction, conferencing, and group collaboration through technology enabled spaces as outlined in the specifications and indicated on the drawings.
- B. The Audiovisual (AV) system shall be a turn-key job to be provided using one vendor. The selected Vendor will provide equipment, labor, installation materials, programming, testing, training, and continued support after substantial completion for the audiovisual systems as outlined in the specifications and indicated on the drawings.

1.2 DESCRIPTION OF WORK

- A. Provide all labor, equipment, supplies and materials for the complete installation of fully functional audiovisual systems in accordance with the Contract Documents. The work includes the following, as well as work not listed below but described elsewhere as it applies to all audio, video, and control systems:
 - 1. Audio, video, and control cabling
 - 2. Equipment Racks and Cabinets
 - 3. Source and head-end equipment
 - 4. Field devices
 - 5. Systems Testing
 - 6. Documentation and submissions
- B. Work includes furnishing and installing all racks, conduit, boxes, raceways, wiring, pull lines, field devices, head end, ground lugs, and receptacles, etc. as shown on the drawings and specified herein. Installation of all specified equipment and final adjustments are part of this specification.
- C. The Contractor shall furnish all cable, material and equipment, whether specifically mentioned herein or not, to insure complete and functional systems.
- D. The Contractor shall inspect architectural, electrical and other trade drawings for dimensions, location of partitions and walls, structural details and location of mechanical pipes and ducts, so that the installation shall be in harmony with the building mechanical systems.

- E. The Contractor is responsible for making all field measurements necessary for establishing the exact locations and relationships necessary for the installation of their equipment.

1.3 RELATED DOCUMENTS

A. General

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

1.4 QUALITY ASSURANCE

A. General Equipment:

- 1. Furnish and install only new equipment and materials required (less than 1 year from manufacture), unused without blemish or defect.
- 2. Each major component of equipment shall have the manufacturer's name, address, model number, and rating on a plate securely affixed in a conspicuous place. The nameplate of a distributing agent will not be acceptable. NEMA Code Ratings, UL label, or other data which is die-stamped into the surface of the equipment shall be stamped in a location easily visible. Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases, equipment is oversized to allow for pickup loads which cannot be delineated under the minimum performance.
- 3. All equipment of the same type shall be the product of one manufacturer.
- 4. The original factory condition of manufactured equipment shall not be modified without the written approval of the Engineer.

B. Contractor & Installer Qualifications:

- 1. The Contractor shall have a minimum of 5-years' experience in completing Audiovisual projects of equal scope, quality, type, and complexity to that required herein.
- 2. The Contractor shall be a member in good standing in an industry recognized trade organization such as the International Communications Industries Association, National Association of Broadcasters, or National Systems Contractors Association for at least 5 years prior to bid time. Provide verification of membership.
- 3. The Contractor will own, at time of bid, all required testing equipment called for in the specifications. Technicians responsible for operating testing equipment will have successfully completed all manufacturers approved training courses for the successful operation of the testing equipment.
- 4. The Contractor shall be an authorized dealer for at least 75% of the equipment specified for at least one year prior to bid time.

5. The principal members and key personnel to be assigned to the project shall each have a minimum of 10-years' experience in completing Audiovisual projects of equal scope, quality, type, and complexity to that required herein.
 6. Minimum of five audiovisual systems, of similar size and scope, installed and operational for a minimum of one year.
 7. Project Lead Technician:
 - a. Trained and certified by the primary audiovisual product manufacturers specified for the project including all digital signal processors and control systems.
 - b. Minimum 5 years' experience as Lead Technician on Audiovisual System projects of similar size and scope
 - c. NICET Level II, ESPA Certified Electronics Systems Technician L2, or ICIA CTS-I certification.
 8. Project Technicians
 - a. Trained and certified by the Audiovisual System solution manufacturer including all digital signal processors and control systems.
 - b. Minimum 2 years' experience on Audiovisual System projects of similar size and scope.
 - c. NICET Level I, ESPA Certified - Electronic Systems Technician, or ICIA CTS certification.
 9. Local services facility within 50-mile radius of project location.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
1. Include dimensions and data on features, performance, mechanical characteristics, electrical characteristics, ratings, and finishes.
 2. Manufacturer's installation instructions.
 3. Product test compliance certificates if required.
- B. Shop Drawings: For audiovisual. Include plans, elevations, sections, details, and attachments to other work.
1. Location and layout of all field equipment on floor plans. Include all device revisions from addenda.
 2. Large scale (minimum 1/4"=1') floor plan and elevation view drawings of all audiovisual equipment in rooms depicting all racks, consoles, cabinets, equipment, outlets, etc.

3. Size and spacing of all anchors, wall penetrations, joinery construction, etc., required for complete system installation.
4. Sizes, shapes, thickness and finishes of all materials and equipment surfaces.
5. Electrical riser diagrams identifying all signal, power and ground circuitry.
6. Block diagram(s) depicting system integration details.
7. Scaled elevations of all audiovisual equipment racks showing equipment mounting locations (front and rear if any equipment is rear mounted).
8. Wire management details for the installation of cable harnesses inside racks, equipment cabinets, consoles, control panels and other areas of exposed cable.
9. Wiring diagrams for all equipment and devices (active and passive).
 - a. Wiring diagrams are required to show point-to-point connection of all terminations for all devices.
 - b. Indicate wire type used for connection.
 - c. Indicated type of termination to be made (i.e. terminal strip, euro block, XLR, etc.).
10. Scaled layouts of all custom control graphic user interface panels.
11. Scaled layouts of all custom input/output interface panels. Panels should show final descriptive labels and connector type.
12. Installation detail of all surface or flush mounted devices including but not limited to speakers, cameras, projectors, etc. Detail to show all required mounting and suspension hardware, as well as connection made to structure. Provide front, side, and top views.
13. Installation detail of all suspended devices including but not limited to speaker systems, projection systems, etc. Detail to show all required mounting and suspension hardware, as well as connection made to structure. Provide front, side, and top view.
14. Printout of all digital signal processing signal routing.

C. Test Plan and Documentation

1. Submit a complete testing plan for all systems for approval within thirty (30) days of receipt of approved shop drawing/product data submittal.
2. Plan submitted must include shop and field testing of each and every field device and control function.
3. Plan submitted must include examples of testing documentation. Shop testing documentation must be submitted for approval prior to control system shipment to job site. Field testing documentation must be submitted when requesting final Demonstration/Inspection (described below).
4. Detailed testing agenda and testing documentation forms for all systems. Detailed agenda outlining the "hands-on" training sessions to be provided to the Owner/User. The operation, programming/debugging, troubleshooting, repair and maintenance of all systems shall be covered.

D. Training Plan and Documentation

1. Submit a complete training plan for all systems for approval.
2. As a minimum, the plan submitted must include individualized training paths for the following personnel on all aspects of the audiovisual system.

- a. Administrators
 - b. Supervisors
 - c. Operators
 - d. Maintenance Personnel
3. As a minimum, the plan submitted must include the following:
 - a. Proposed classes or sessions.
 - b. Recommended attendees for each class or session.
 - c. Proposed class or session objectives.
 - d. Proposed class or session agenda and duration.
 - e. Proposed supporting materials for each class or session.
 - f. Proposed testing procedure for evaluation purposes.
 - g. Proposed documentation of testing and evaluation.
4. Do not commence training until the plan has been approved.
5. Plan submittal must include names of technical instructors. Contractor must provide engineer responsible for project as instructor. Contractor instructor shall submit evidence of factory training on system provided.

E. Operating and Maintenance Data

1. Provide three (3) copies of each operating and maintenance manual for each 267413 series system. Manuals shall be bound in "D-ring" binders with a detailed table of contents.
2. The O&M manuals shall be cross-referenced to the Record Documents and contain the following information for all systems:
 - a. Product catalog cut sheets and specifications of all equipment.
 - b. "Hands-on" operational description of all equipment and performance features in each system using clear and understandable terminology.
 - c. Detailed programming instructions for all systems and all software programs.
 - d. Printed copy of all equipment settings. This is to include the final settings for all source level control, analog and digital processing, and amplification.
 - e. Copy of all software programs required for any digital signal processing stored on CD or USB memory stick. Provide one copy for each O&M Manual, and one copy that are to be left in the rear of the equipment rack.
 - f. Troubleshooting procedures to diagnose malfunctions in each system.
 - g. Repair procedures for all equipment.
 - h. Preventative maintenance procedures for all equipment.
 - i. Table listing the model numbers for all equipment in each system including the names and phone numbers of the manufacturer and their representative directly responsible for this project.
 - j. Provide laminated quick start/instruction guide for each space containing AV technology, to be no more than one page front and back.

F. Record Documents

1. Submit one (1) sepia copy and one (1) blue line print of the "As-built" condition of all systems including:

- a. A set of updated shop drawings showing all Contract changes.
 - b. A set of updated product data showing all Contract changes.
 - c. Floor plan showing conduit raceway routing including all equipment rack, cabinet and pull box locations, and conduit sizes.
 - d. Complete point-to-point wiring diagrams showing ALL equipment, devices, wire and cable (Signal, power and ground). This document shall also include all terminal block designations, abbreviations and color-coding.
 - e. Two (2) copies of training session video tapes.
 - f. Transmittal letter listing delivery of complete spare parts inventory
2. Submit one (1) copy of finalized as-built drawings to NHC ITS department.

1.6 COORDINATION

- A. Audiovisual Construction Kick-off Review Meeting: Within 2 weeks of Notice to Proceed, Engineer will conduct a mandatory audiovisual kick-off meeting to discuss scope of project, submittal requirements, and project execution expectations.
- B. Audiovisual Product Data/Shop Drawing Review Meeting: Prior to final acceptance of the audiovisual product data and shop drawing package, Engineer will conduct a mandatory pre-submittal meeting. The Contractor and audiovisual lead installation technician shall attend and review the product data and shop drawing package with NHC.
- C. Audiovisual Pre-Testing & Demonstration Meeting: Two weeks prior to start of Engineer Testing & Demonstration, Engineer will conduct a mandatory meeting to review demonstration procedures and insure Contractor understands the intent and goal of the demonstration process.
- D. Field Coordination: Coordinate layout and installation of audiovisual equipment and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.7 WARRANTY

- A. Warranty
 1. The audiovisual system shall be fully guaranteed for a period of two (2) years beginning of the date of Owner acceptance. The option for a third year of warranty and associated pricing shall be included for the owner to review for acceptance.
 2. The guarantee shall include the entire scope of work defined in this specification including all equipment, devices, materials, cable/wire, software, and installation.
 3. Work shall be guaranteed to be free from defects. Any defective materials or workmanship, as well as damage to the work of all other trades resulting from the same, shall be replaced or repaired as directed by the Owner for a period of two (2) years from the date of Owner final acceptance. The Contractor shall provide written warranties for all systems and all buildings to the Owner.
 4. The guarantee shall exclude acts of God, vandalism, physical abuse or operator misuse.

5. Acceptance by a manufacturer of an order for equipment for this contract signifies acceptance of this warranty. During the warranty period there shall be no charge to the owner for equipment, material, software, etc. for guarantee work.
6. During the warranty period, there shall be no charges to the Owner for service calls (mileage, labor, travel, expenses, etc.) for guaranteed work.

B. Warranty Service

1. Warranty service shall be provided as part of this Contract by the Contractor during the warranty period.
2. Warranty service agreement must be submitted separately and must contain the name, voice phone number, facsimile phone number and pager number of the service provider capable of meeting the response time as defined by the Engineer.
3. This service shall consist of the following:
 - a. 24-hour phone number.
 - b. Technician's factory trained by the manufacturers of the system's components.
 - c. Authorized representation of the manufacturer via an agreement of factory support.
 - d. Five years' experience (minimum) servicing systems of the type included in this project.
 - e. Capability of making additions or changes to the software systems used in this project.
 - f. Capability of servicing the individual system components and the total audio/visual system.
 - g. Equipment and knowledge to test all specified equipment and devices.
 - h. Current system documentation including but not limited to the following:
 - 1) Wiring diagrams.
 - 2) Operation and maintenance manuals.
 - 3) Software programs.
 - 4) Other documentation as required to provide assistance to the owner in the operation and maintenance of the systems.
 - 5) All documents shall be made available to Owner upon request.
 - 6) Upon termination of maintenance agreement all system documents shall be furnished to owner for maintenance continuity.
4. The Owner and/or Architect shall notify the Contractor in writing, outlining operational malfunctions or defects in the Division 27 4100 series audiovisual system. This report shall be faxed to the service provider which will establish the date and time of problem notification.
5. Upon successful completion of warranty service, the responsible technician shall return a copy of the original service request to the facility with a detailed description of the problem found, and corrective action taken including a list of equipment/parts/software repaired or replaced. The technician shall also sign the on-site service log at the facility.
6. The Contractor shall maintain a repair parts inventory sufficient to maintain the response times specified. All parts used from the Owner's spare parts inventory for warranty service shall be replaced at no cost to the Owner.

7. Response Times:

- a. Telephone Call Response: Within 1 hour of request
- b. On-Site Response:
 - 1) M-F 8:00 a.m. to 5:00p.m. - Within 4 hours of request
 - 2) Saturday, Sunday or after 5:00p.m. – Response next calendar day

1.8 SPARE PARTS

- A. Provide spare parts as described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Provide not less than one of each item listed below. Deliver extra materials to owner.

- 1. One manufacturer recommended spare lamp for each projector installed.

1.9 AUDIOVISUAL SYSTEM DESCRIPTIONS

A. MESSAGE System:

- 1. Display system will consist of one wall mounted flat panel display with mounting hardware.
- 2. All audiovisual system equipment including source devices and user interfaces will be mounted inside wall box behind flat panel display.
- 3. Data cabling provided by electrical contractor to wall box. Connect cabling to flat panel display to support the system.
- 4. Owner will select owner furnished master terminals for programming of each messaging display.
- 5. Owner shall provide data messaging system in telecom rack for programming.

B. COLLABORATION System:

- 1. Display system will consist of one wall mounted flat panel display with mounting hardware. Mounting hardware shall allow for display to rotate for multiple angles of view in the space.
- 2. System will accommodate HDMI and VGA video sources using an audio/video switcher. Video sources shall include digital and analog connections to a removable visitor laptop, HDMI Mini Display Port for removable visitor device, and a Blu-Ray Player.
- 3. A recessed cable cubby with touch screen control panel will be provided in the surface of the table. Power, network connections, and auxiliary connections for portable devices will be located in the cable cubby.
- 4. Control of the audiovisual system shall be performed through a touch screen control panel located on the surface of the table.
- 5. A power over Ethernet (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at audiovisual rack.
- 6. All audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces shall be housed in room rack.

7. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

C. DIVISIBLE PROJECTION System:

1. The display system shall consist of a pair of projection screens and projectors in divisible program room. The projection screens will be an electrically operated screen and will accommodate a 16:10 format. The projectors will be a ceiling mounted type and project images onto the projection screen. The projectors will utilize HDBaseT connection and connected to the audio/video switcher using DTP cabling.
2. System will accommodate HDMI and VGA video sources using an audio/video switcher. Video sources shall include digital and analog connections to a removable visitor laptop, HDMI Mini Display Port for removable visitor device, and Blu-Ray Player.
3. Wall mounted outlets will be provided in the front of the space for connection to the system. Power, network connections, and auxiliary connections for portable devices will be located at this location.
4. The audio system will consist of a distributed overhead speaker system. Rooms with acoustic tile ceilings will be equipped with compact recessed ceiling speakers. Refer to plans for quantity and location of speakers.
5. Audio system shall be programmable such that when room is divided, audio from each projection system will be isolated to each space using local speakers. When room is not divided, audio shall utilize all speakers for programming from main projection system.
6. Program audio sources will include video sources and computer sources.
7. Amplifier will be used to power the speaker system.
8. Participant wireless microphones and charging stations shall be located in each space. Wireless receiver for the audiovisual system shall be located in the rack. Individual microphones shall be programmed for use in a defined space.
9. A control system will be used to operate the video projector switcher.
10. Control of the audiovisual system shall be performed through a control touch screen located on the wall in the front of the space.
11. A network (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at the rack.
12. The room rack will house all audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces. An equipment rack will be provided in the adjacent room to store all audiovisual rack equipment.
13. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

D. TOUCH SCREEN System:

1. Display system will consist of one wall mounted touch screen flat panel display with mounting hardware.
2. All audiovisual system equipment including source devices and user interfaces will be mounted inside wall box behind flat panel display.
3. Data cabling provided by electrical contractor to wall box. Connect cabling to flat panel display to support the system.

4. Control of the audiovisual system shall be performed through an adjacent wall mounted control button panel.
5. Control button panel shall allow ON/OFF function of display, volume control, and source selection.
6. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

E. PROJECTION System:

1. The display system shall consist of a pair of one projection screen and one projector. The projection screen will be an electrically operated screen and will accommodate a 16:10 format. The projector will be a ceiling mounted type and project images onto the projection screen. The projector will utilize HDBaseT connection and connected to the audio/video switcher using DTP cabling.
2. System will accommodate HDMI and VGA video sources using an audio/video switcher. Video sources shall include digital and analog connections to a removable visitor laptop, HDMI Mini Display Port for removable visitor device, and Blu-Ray Player.
3. Wall mounted outlets will be provided in the front of the space for connection to the system. Power, network connections, and auxiliary connections for portable devices will be located at this location.
4. The audio system will consist of a distributed overhead speaker system. Rooms with acoustic tile ceilings will be equipped with compact recessed ceiling speakers. Refer to plans for quantity and location of speakers.
5. Program audio sources will include video sources and computer sources.
6. Amplifier will be used to power the speaker system.
7. A control system will be used to operate the video projector switcher.
8. A media controller mounted to the wall will be used to control the "on/off", the media source input, and volume control of flat panel display.
9. A network (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at the rack.
10. The room rack will house all audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces. An equipment rack will be provided in the room to store all audiovisual rack equipment.
11. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

F. CONFERENCE System:

1. Display system will consist of one wall mounted flat panel display with mounting hardware.
2. System will accommodate HDMI and VGA video sources using an audio/video switcher. Video sources shall include digital and analog connections to a removable visitor laptop, HDMI Mini Display Port for removable visitor device, and owner furnished PC.
3. A fixed position video camera shall be wall mounted beneath the flat panel display to capture room participants.
4. Soft-codec based video conferencing shall be accomplished through the use of the Owner furnished computer and Owner software applications.

5. A recessed cable cubby with touch screen control panel will be provided in the surface of the table. Power, network connections, and auxiliary connections for portable devices will be located in the cable cubby.
6. Control of the audiovisual system shall be performed through a touch screen control panel located on the surface of the table.
7. A power over Ethernet (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at audiovisual rack.
8. The room rack will house all audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces. An equipment rack will be provided in the casework to store all audiovisual rack equipment.
9. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

G. STUDY System:

1. Display system will consist of one wall mounted flat panel display with mounting hardware.
2. Display will be built in wireless board to allow up to 10 user devices connection via wireless connectivity.
3. System will accommodate HDMI video sources. Video sources shall include digital connections to flat panel display using owner furnished HDMI connection cables.
4. A media controller mounted to the wall will be used to control the "on/off", the media source input, and volume control of flat panel display.
5. Provide complete cable plant required to support the system. This includes all control and signal cable.

H. TEEN COLLABORATION System:

1. Display system will consist of one wall mounted flat panel display with mounting hardware.
2. System will accommodate HDMI video sources using an audio/video switcher. Video sources shall include digital connections to flat panel display using owner furnished gaming consoles and a presentation gateway (ShareLink) system.
3. Control of the audiovisual system shall be performed through a control touch screen located on the wall adjacent to the display.
4. A power over Ethernet (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at audiovisual rack.
5. The room rack will house all audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces. An equipment rack will be provided in the rack to store all audiovisual rack equipment.
6. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

I. MAKER COLLABORATION System:

1. Display system will consist of one wall mounted flat panel display with mounting hardware.
2. System will accommodate HDMI and VGA video sources using an audio/video switcher. Video sources shall include digital and analog connections to a

- removable visitor laptop, HDMI Mini Display Port for removable visitor device, owner furnished PC, and a Blu-Ray Player.
3. A recessed cable cubby with touch screen control panel will be provided in the surface of the table. Power, network connections, and auxiliary connections for portable devices will be located in the cable cubby.
 4. Control of the audiovisual system shall be performed through a touch screen control panel located on the surface of the table.
 5. A power over Ethernet (PoE) switch will be provided for connectivity of audiovisual devices. The PoE switch will be connected to the local area network (LAN) using CAT-6 cable and data outlet at audiovisual rack.
 6. All Audiovisual system equipment including source devices, rack-mounted equipment, and user interfaces shall be housed beneath the room table. An equipment rack will be provided beneath the room table to store all audiovisual rack equipment.
 7. Provide complete cable plant required to support the system. This includes all control, signal, and speaker cable.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design: Extron
 1. Available Manufacturers: Crestron, AMX
- B. Available Manufacturers and Products: Subject to compliance with requirements, other manufacturers and respective products may be incorporated provided the following:
 1. It is the intent of the specifications to denote the Basis of Design and quality standard of product desired and not to restrict bidders to a specific brand, make, manufacturer or specific name. The manufacturer listed above is used only to set forth and convey to bidders the general style, type, character, and quality of product desired. Substitution of equivalent products will be acceptable according to the following paragraph.
- C. Substitution of Equivalent Products: Substitution of manufacturers and products equivalent to those listed above shall be submitted to the Engineer for approval more than 10 days prior to Bid Date. Submittal shall include all items listed in Article 1.4A. Owner and Engineer has final authority on equivalence and acceptance.

2.2 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts are readily available.
- B. Equipment Assemblies and Components

1. All components of an assembled unit need not be products of the same Manufacturer; however, all components must be acceptable to the Engineer.
 2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
 3. When more than one unit of the same class of equipment or material is required, such units shall be the products of a single manufacturer.
 4. Components shall be compatible with each other and with the total assembly for the intended service.
 5. Constituent parts which are similar shall be the product of a single manufacturer.
- C. All factory wiring shall be identified on or provided with the equipment being furnished and on all wiring diagrams and included with O&M manuals.
- D. When factory testing is specified
1. The Engineer shall have the option of witnessing factory tests. The contractor shall notify the Engineer a minimum of 15 working days prior to the manufacturers making the factory tests.
 2. Four copies of certified test reports containing all test data shall be furnished to the Engineer prior to final inspection and not more than 90 days after completion of tests.
 3. When equipment fails to meet factory test and re-inspection is required, the CONTRACTOR shall be liable for all additional expenses.

2.3 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the National Electrical Code, install an identification sign which will clearly indicate information required for use and maintenance of items such as cabinets, control devices and other significant equipment.
- B. Nameplates shall be laminated black phenolic resin with a white core and engraved lettering, a minimum of 1/4-inch high. Nameplates that are furnished by manufacturer, as a standard catalog item, or where other methods of identification are herein specified, are exceptions.
- C. All inputs and outputs are to be clearly labeled. Inputs to include the source location and signal type. Outputs should indicate location signal is sent to.
- D. All custom input plates labeling shall be engraved and paint filled or laser etched with a contrasting color as shown on the specification.
- E. Any and all user serviceable devices shall be clearly labeled

2.4 CEILING MOUNTED PROJECTOR

- A. Basis of Design: Epson PowerLite Pro G6070W WXGA 3LCD with Standard Lens
- B. Approved Equals: NEC, Panasonic.

C. Specifications:

1. Brightness: 5500 lumens
2. Contrast Ratio: 5000:1
3. Zoom: Manual
4. Focus: Manual
5. Focal Length: 21.28mm – 37.94mm
6. Zoom Ratio: Optical Zoom 1 – 1.8
7. Throw Range: 1.26 – 2.76
8. Lamp Type: 380 W UHE
9. Lamp Life (ECO Mode/Normal): Up to 4000/3000 hours
10. Aspect Ratio: Supports 4:3, 16:9, 16:10
11. Projection Screen Size: 50 – 300" diagonal
12. Projection Range: 94", 8'-6"; 137", 12'-5"
13. Projection System: High-aperture Epson 3LCD. 3-chip technology
14. Color Reproduction: Up to 1 billion colors
15. Keystone Correction: 30° Vertical, 30° Horizontal
16. Dimensions: 19.88" x 15.04" x 5.67"
17. Weight: 19.6 lbs.
18. Inputs: HDBaseT, HDMI, Display Port, Composite, and RGB/Component.

2.5 PROJECTION SCREEN

A. Basis of Design: Draper – Access V

B. Approved Equals: Stewart Filmscreen Co., Da-Lite Screen Company.

C. Specifications:

1. General: Manufacturer's standard units consisting of case, screen, motor, controls, mounting accessories, and other components necessary for a complete installation. Provide units that are listed and labeled as an assembly by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
 - 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. Controls: Remote, three-position control switch installed in recessed device box with flush cover plate matching other electrical device cover plates in room where switch is installed.
 - 1) Provide number of control switches indicated for each screen.
 - 2) Provide power supply for low-voltage systems if required.
 - 3) Provide locking cover plates for switches.
 - 4) Provide infrared remote control consisting of battery-powered transmitter and receiver.
 - 5) Provide video interface control for connecting to equipment. equipment provides signal to raise or lower screen.
 - c. Motor in Roller: Instant-reversing motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically

- stop screen in up and down positions, and positive-stop action to prevent coasting. Mount motor inside roller with vibration isolators to reduce noise transmission.
 - d. Screen Mounting: Top edge securely anchored to rigid metal roller and bottom edge formed into a pocket holding a 3/8-inch- diameter metal rod with ends of rod protected by plastic caps.
 - 1) Roller for motor in roller is supported by vibration- and noise-absorbing supports.
 - e. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen that is connected to edge of screen by tabs to pull screen flat horizontally.
2. Suspended, Electrically Operated Screens without Ceiling Closure, with Motor-in-Roller, and with Tab Tensioning: Units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.
- a. Provide metal or metal-lined wiring compartment.
 - b. Screen Case: Made from metal.
 - c. Provide screen case with trim flange to receive ceiling finish.
 - d. Finish on Exposed Surfaces: Vinyl covering or baked enamel
3. FRONT-PROJECTION SCREEN MATERIAL
- a. Matte Reflective Viewing Surface: Peak gain of not less than 1.3, and half-gain angle of at least 40 degrees from the axis of the screen surface.
 - b. Material: Vinyl-coated, glass-fiber fabric.
 - c. Mildew-Resistance Rating: Zero or 1 when tested according to ASTM G 21.
 - d. Flame Resistance: Passes NFPA 701.
 - e. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
 - f. Seams: Where length of screen indicated exceeds maximum length produced without seams in material specified, provide screen with horizontal seam placed as follows:
 - 1) At bottom of screen at juncture between extra drop length and viewing surface.
 - 2) In location indicated.
 - g. Seamless Construction: Provide screens, in sizes indicated, without seams.
 - h. Edge Treatment: Black masking borders.
 - i. Size of Viewing Surface: As indicated.
 - j. Provide extra drop length of dimensions and at locations indicated.
 - 1) Color: Black.

2.6 MEDIA PRESENTATION SWITCHER

- A. Basis of Design: Extron IN1608 HDBT, part number 60-1238-71
- B. Approved Equals: Brand Specific
- C. Specifications:

1. Provide a video scaling presentation switcher that shall support up to eight inputs and three outputs for processing and switching of HDMI, HDTV, RGB, and composite video sources, with additional support for signal extension over shielded CATx cable.
2. Rack-mountable scaler and switcher for HDMI, HDTV, RGB, and composite video sources and associated digital and analog audio, plus signal extension over shielded CATx cable.
 - a. Video Input Requirements
 - 1) Provide video input connections
 - a) Four HDMI
 - b) Two 15-pin HD, configurable for RGB, component video, S-video, or composite video.
 - c) Two RJ-45 for video from Extron DTP™ twisted pair transmitters
 - 2) Provide automatic detection of input video parameters.
 - 3) Provide image adjustments for brightness, contrast, color, tint, detail, H/V positioning, and sizing.
 - 4) Provide storage and recall of video parameters and picture settings.
 - 5) Provide enhanced decoding of composite video.
 - 6) Support HDMI specifications including 1080p/60 Deep Color, data rates up to 6.75 Gbps, and HD lossless audio formats.
 - 7) Provide automatic 3:2 and 2:2 pulldown detection.
 - 8) Support video transmission over shielded CATx up to 330 feet (100 meters).
 - b. Video Output Requirements
 - 1) Provide video input connections
 - a) Four HDMI
 - b) Two 15-pin HD, configurable for RGB, component video, S-video, or composite video.
 - c) Two RJ-45 for video from Extron DTP™ twisted pair transmitters
 - 2) Provide a range of selectable video output rates from 640x480 to 1920x1200, including 1080p/60 and 2048x1080p/60.
 - 3) Provide image scaling and video format conversion at 30-bit precision and support 1080i deinterlacing.
 - 4) Provide aspect ratio control.
 - 5) Provide internal test patterns for calibration and setup.
 - 6) Support image freeze via Ethernet, RS-232, or USB connection.
 - 7) Support muting of one or all outputs at any time.
 - 8) Support automatic muting of video and sync output when no video input signal is present.
 - 9) Provide a low power standby state selectable via Ethernet, RS-232, or USB.
 - 10) Support the connection of DVI displays that do not recognize HDMI-specific formats
 - 11) Support video transmission over shielded CATx up to 330 feet (100 meters).
 - c. Switching Requirements
 - 1) Provide automatic switching between input sources.
 - 2) Provide selectable transition effects when switching inputs.
 - d. EDID Requirements
 - 1) Provide automatic EDID management between connected devices.

- e. HDCP Requirements
 - 1) The unit shall be HDCP compliant.
 - 2) Provide real-time verification of HDCP status for each HDMI input and output.
- f. Audio Requirements
 - 1) Provide audio input connections
 - a) Four HDMI, embedded
 - b) Six 5-pole captive screw, balanced/unbalanced line level analog stereo
 - c) Two 3-pole captive screw, mono mic/line level with switchable 48 V phantom power
 - d) Two RJ-45, DTP HDMI embedded and analog audio
 - 2) Provide audio output connections
 - a) Two simultaneous HDMI, embedded
 - b) Two 5-pole captive screw, with independent output level control and configurable for balanced/unbalanced, analog stereo, or independently mixed analog mono
 - c) One RJ-45, HDBaseT embedded audio
 - 3) Support embedding of any analog audio input signal onto the HDMI outputs
 - 4) Support extraction of two-channel LPCM HDMI audio signals to the analog stereo outputs, or pass bitstream audio to the HDMI outputs
 - 5) Support mixing of program audio with two mic/line inputs, providing three simultaneously available, independently mixed outputs
 - a) Stereo output to HDMI
 - b) Stereo analog audio output
 - c) Stereo or dual mono analog audio output
 - 6) Provide the capability to break an analog audio signal away from its corresponding video signal and route to the audio outputs, allowing the analog audio channels to be operated as a separate switcher.
 - 7) Provide a delay in the audio output to match the corresponding video processing delay.
 - 8) Provide gain and attenuation adjustments for analog or embedded HDMI input audio.
 - 9) Support individual muting of the analog stereo or HDMI audio inputs.
- g. Control/Remote – RS-232 and IR Pass-Through Over Shielded CATx Requirements
 - 1) Provide connections for device control
 - a) Two 5-pole captive screw: RS-232 or IR pass-through to DTP twisted pair transmitters
 - b) One 5-pole captive screw: RS-232 or IR pass-through to HDBaseT-enabled display
 - 2) Support RS-232 and IR transmission over shielded CATx up to 330 feet (100 meters)
- h. Control Remote – Switcher Control Requirements
 - 1) Provide connections for remote switcher control.
 - a) RJ-45: 10/100Base-T Ethernet
 - b) 3-pole captive screw: RS-232
 - c) Mini USB-B: USB 2.0
 - 2) Provide alternatives for configuration and operation.

- 3) Support disabling of front panel controls to prevent inadvertent or unauthorized changes to configuration settings.
- i. General Requirements
 - 1) Provide real-time verification of signal flow and operation from DTP and HDBaseT connections.
 - 2) DTP inputs shall be compatible with all Extron DTP Series transmitters and DTP-enabled products.
 - 3) Support sending digital video and embedded audio, plus bidirectional RS-232 and IR signals to an HDBaseT-enabled display,
 - 4) Shall be compatible with CATx shielded twisted pair cable, and Extron XTP DTP 24 shielded twisted pair cable.
 - 5) Shall provide remote power to two remote DTP transmitters over the shielded CATx connections.
 - 6) Enclosure shall be rack-mountable, full rack width, and 1RU in height.
 - 7) Shall be equipped with an internal 100-240 VAC, 50/60 Hz universal power supply.

2.7 MATRIX SWITCHER

A. Basis of Design: Extron DTP CrossPoint 84 IPCP MA 70, part number 60-1368-13

B. Approved Equals: Brand Specific

C. Specifications:

1. Provide an 8x4 scaling presentation matrix switcher that shall support up to eight inputs and four outputs for matrix switching of HDMI sources, one digital audio expansion port, one integrated Extron IPCP Pro 350 control processor, plus additional support for signal extension over shielded CATx cable and audio digital signal processing.
2. Rack-mountable matrix switcher for HDMI video sources and associated digital and analog audio, plus system control, signal extension over shielded CATx cable, and audio digital signal processing
3. Video Input Requirements
 - a. Provide video input connections
 - 1) Six HDMI
 - 2) Two RJ-45 for video from Extron DTP™ twisted pair transmitters
 - a) Shall be configurable for compatibility with Extron DTP transmitters or DTP-enabled products
 - b) Shall be configurable for compatibility with Extron XTP® CrossPoint® matrix switchers
 - b. Support 4K and UHD signals at all inputs
 - c. Provide image adjustments for the DTP outputs, including brightness, contrast, color, tint, detail, H/V positioning, and sizing
 - d. Provide storage and recall of video parameters and picture settings when activated for the scaled DTP outputs
 - 1) Automatic memories for each video input
 - a) Set video settings and picture adjustments without user intervention

- b) Automatically recall settings when the same video rate is encountered
 - c) The user may selectively enable or disable automatic memories
 - 2) Manual user presets
 - a) Set picture adjustments
 - b) User presets may be set and recalled using front panel controls
 - c) User presets may be set and recalled electronically via Ethernet, RS-232, or USB connection
 - 3) Manual input presets
 - a) Set video settings and picture adjustments
 - b) Input presets may be set and recalled electronically via Ethernet, RS-232, or USB connection
 - e. Support HDMI specifications including data rates up to 10.2 Gbps, Deep Color up to 12-bit, 3D, and HD lossless audio formats
 - f. Provide automatic cable equalization for each digital input to 100 feet (30 meters) at 1080p/60 with 8-bit color when used with Extron HDMI Pro cables
 - g. Provide automatic cable equalization for each digital input to 50 feet (15 meters) at 4K/30 and 2560x1600 @ 60 Hz resolutions when used with Extron HDMI Pro cables
 - h. Support video transmission over shielded CATx up to 330 feet (100 meters)
- 4. Video Output Requirements
 - a. Provide video output connections
 - 1) Two HDMI
 - 2) Two RJ-45 for video to Extron DTP twisted pair receivers
 - a) Shall be configurable for compatibility with Extron DTP receivers or DTP-enabled products
 - b) Shall be configurable for sending digital video and embedded audio, plus bidirectional RS-232 and IR signals to Extron XTP CrossPoint matrix switchers
 - c) Shall be configurable for sending digital video and embedded audio, plus bidirectional RS-232 and IR signals to HDBaseT-enabled displays
 - b. Provide a range of selectable scaled DTP output rates from 640x480 to 1920x1200, including 1080p/60 and 2048x1080p/60
 - c. Support 4K and UHD signals at both HDMI outputs
 - d. Provide independent scaling for each DTP output
 - e. Provide aspect ratio control for each scaled DTP output
 - 1) When in FILL mode, the video image shall always fill the output screen without letterbox or pillarbox
 - 2) When in FOLLOW mode, the video image shall always preserve the aspect ratio of the input signals without distortion
 - f. Provide internal test patterns for the scaled DTP outputs to facilitate system setup and calibration
 - g. Support muting of one or all outputs at any time
 - h. Support automatic muting of video and sync output when no video signal is present
 - 1) Provide a choice to generate a blue screen or a black screen before disabling sync
 - 2) Provide a configurable timeout period before disabling sync
 - 3) The user may selectively enable or disable automatic muting of sync output

- i. Support the connection of DVI displays that do not recognize HDMI-specific formats
 - 1) Automatically enable or disable embedded TMDS audio and InfoFrames
 - 2) Automatically set the correct color space
 - j. Support video transmission over shielded CATx up to 330 feet (100 meters)
 - k. Provide automatic reclocking of HDMI video signals at each HDMI output
- 5. Switching Requirements
 - a. Provide video and audio matrix switching between any input and any output
 - 1) Support incoming 4K and UHD signals at all HDMI and DTP inputs
 - 2) Support routing of 4K and UHD signals to both HDMI outputs
 - b. Provide storage and recall of input and output ties
 - 1) Set video and audio ties between inputs and outputs
 - 2) Global presets may be recalled using front panel controls
 - 3) Global presets may be set and recalled electronically via Ethernet, RS-232, or USB connection
 - c. Provide the ability to view which inputs and outputs are actively connected
- 6. EDID Requirements
 - a. Provide automatic EDID management between connected devices
 - 1) Provide a set of pre-stored EDID files
 - 2) Support capture of EDID from any connected display
 - 3) Support user uploading of custom-generated EDID files
 - 4) Support assignment of pre-stored, captured, or custom uploaded EDID file for each input connection
- 7. HDCP Requirements
 - a. The unit shall be HDCP compliant
 - 1) Provide authentication and maintain continuous verification of HDCP key exchange with connected sink devices
 - 2) Provide authentication and maintain continuous verification of HDCP key exchange with connected source devices
 - 3) Provide the option to disable HDCP processing at any HDMI input connection when passing unencrypted content
 - 4) Provide selectable, human-readable visual confirmation of HDCP compliance when encrypted content is routed to a non-HDCP compliant display
 - a) When enabled, the video output shall be a solid green color and an on-screen message stating "HDCP CONTENT" shall be displayed
 - b) When disabled, the output shall be muted
 - b. Provide real-time verification of HDCP status for each HDMI input and output
 - 1) Electronically accessible over Ethernet, RS-232, or USB connection
- 8. Audio Requirements
 - a. Provide audio input connections
 - 1) Support embedded audio on six HDMI connectors
 - 2) Support embedded audio on two RJ-45 connectors
 - 3) Support six stereo, line level, balanced or unbalanced signals on six, 5-pole, 3.5 mm captive screw connectors
 - 4) Support four mono, microphone or line level, balanced or unbalanced signals with +48 volt phantom power on four, 3-pole 3.5 mm captive screw connectors
 - b. Provide audio output connections

- 1) Support embedded audio on two HDMI connectors
- 2) Support embedded audio on two RJ-45 connectors
- 3) Support four stereo line level, balanced or unbalanced signals with independent output level control on four, 5-pole 3.5 mm captive screw connectors
- 4) Support S/PDIF digital audio signal on one RCA connector
- 5) Support one mono speaker level signal on one 2-pole, 5 mm screw-lock captive screw connector
- c. Provide mono amplification for high impedance speaker systems
 - 1) Support one mono speaker level signal on one 2-pole, 5 mm screw-lock captive screw connector
 - 2) Provide a total of 100 watts rms output power into a 70 volt load, measured at 1 kHz with 0.1% THD
 - 3) Provide a THD+N measurement of less than 0.1% measured at 3 dB below clipping
 - 4) Provide a signal-to-noise ratio of greater than 90 dB measured from 20 Hz to 20 kHz, unweighted
 - 5) Utilize an efficient Class D amplifier design
 - 6) Provide Class D Ripple Suppression technology
 - 7) Shall be convection cooled and operate without fans
 - 8) Provide an automatic clip limiter to detect onset of clipping by comparing input and output waveforms and automatically reduce gain with a slow attack and fast release to eliminate clipping distortion
 - 9) Provide multiple protection circuits that activate during output shorts, thermal overload, or DC faults
- d. Provide 64-bit floating point DSP engine
 - 1) Support 32-bit and 64-bit processing algorithms
 - 2) Provide a maximum, deterministic latency of 4.5 ms from input to output
 - 3) Provide additional, deterministic latency of 2 ms when Virtual Path routing is used
- e. Support embedding of any analog audio input signal onto the HDMI outputs
- f. Support extraction of two-channel PCM HDMI audio signals to the analog stereo outputs, or route embedded multi-channel bitstream audio to the HDMI outputs
- g. Support de-embedding, processing, and re-embedding of two-channel PCM HDMI audio signals onto the HDMI outputs
- h. Support mixing of program audio and mic/line audio signals
- i. Support mic audio mixed with program audio onto the HDMI/DTP outputs, variable audio outputs, S/PDIF audio output, and amplified audio output
- j. Provide the capability to break two-channel audio away from its corresponding video signal and route to the audio outputs, allowing the audio and video signals from one source to be switched to different destinations
- k. Provide adjustable, automatic ducking of program audio when a signal is detected on the microphone input
 - 1) Program audio shall automatically ramp up to reach the original volume level when audio is no longer detected on the microphone input
- l. Support audio transmission over twisted pair up to 330 feet (100 meters)
9. Expansion Port Requirements

- a. Provide a digital audio expansion port for bidirectional signal routing between the matrix switcher and a connected Extron DMP 128 Digital Matrix Processor
 - b. Support 16 incoming signals and 8 outgoing signals
 - c. Provide uncompressed digital audio at 48 kHz sampling rate with 24-bit resolution
10. DSP Configuration Software Requirements
- a. Shall support PC-based DSP configuration software, allowing flexible control of the integrated digital signal processing
 - 1) Shall provide a Live mode for real-time control of parameters without compiling and file uploading to matrix switcher
 - 2) Shall provide an Emulate mode for offline configuration
 - 3) Shall provide single window view of all inputs and outputs, audio processing blocks, routing, mix points, and virtual routing
 - 4) Shall provide setup and configuration of digital signal processing tools including, but not limited to: Filters (high pass, low pass, bass, treble, and parametric EQ); Dynamics processing (AGC, compressor, limiter, noise gate); Delay processing; Ducking processor; Loudness processor; and multiple gain stages
 - 5) Shall provide cut and paste editing between processing blocks
 - 6) Shall provide matrix routing with integrated mix point gain adjustment between inputs, outputs, virtual sends, virtual returns, expansion inputs, and expansion outputs
 - 7) Shall provide a library of pre-designed processor settings for inputs and outputs with user-customizable parameters
 - 8) Shall provide 32 Group Master controls for consolidation of up to 28 individual gain or mute control members of the same type into one point of control
 - 9) Shall provide Soft Limits settings to define upper and lower control limits on Group Masters for use with external controls
 - 10) Shall provide 32 Presets for recall of any processing block setting, level setting, or audio routing; presets shall be set for the entire system, or any selected partial groups of inputs, outputs, mix points, and DSP blocks
 - 11) Shall provide real-time metering of levels within each Input Gain, AGC, Compressor, Limiter, Noise Gate, and Output Volume processing block in Live mode
 - 12) Shall provide a Meter Bridge window for real-time metering of all input and output channels with clipping indication in Live mode
 - 13) Shall provide keyboard-based migration of configuration software utilizing directional controls, keyboard shortcuts, and spreadsheet software-style commands
 - 14) Shall provide file save in both Live and Emulate mode
 - 15) Shall provide file upload in both Live and Emulate mode
 - 16) Shall provide configuration and file save of the matrix switcher and a linked, compatible Extron digital matrix processor from a single configuration software session
11. Integrated Control Processor Requirements
- a. Provide system control connections
 - 1) Three RJ-45: 10/100/1000Base-T Ethernet

- 2) Shall support connection of Extron TouchLink® Pro touchpanels and other network controlled devices
 - 3) Shall act as a three port unmanaged network switch
 - 4) Two 3-pole captive screw: RS-232, configurable for unidirectional or bidirectional control of system components
 - 5) One 5-pole captive screw: RS-232/RS-422/RS-485, configurable for unidirectional or bidirectional control of system components
 - 6) Two IR/serial ports on one 5-pole captive screw: IR (using an IR emitter) or unidirectional RS-232 for control of system components
 - 7) Four low voltage relays on one 6-pole captive screw: configurable for controlling lighting, controlling screens, or other device functions
 - 8) Four digital input/output ports on one 5-pole captive screw: configurable for use as an interface with devices such as sensors, switches, LEDs, and relays
 - b. Shall support the following protocols: ICMP (ping), IPv4, TCP, UDP, DHCP, DNS, HTTP, HTTPS, NTP, SFTP, SMTP, SNMP, SSH
 - c. Shall support a Web-based resource management application that provides a means to manage, monitor, and control equipment
 - d. Provide an internal real-time clock with a 30-year backup battery that is used to keep track of the date and time
 - e. Shall support the addition of an Extron LinkLicense™ for use of third party devices as primary control interfaces
 - f. Provide front panel LED activity indicators for RS-232 status, RS-232/RS-422/RS-485 status, IR/serial status, digital I/O status, relay status, and network status
 - g. Shall support control system synchronization to allow users to retain and recover configured endpoints in case of network or power failure
 - h. Shall be configured using Extron Global Configurator™ Plus or Extron Global Configurator Professional with support for the following:
 - 1) Provide support for up to eight configurable Extron TouchLink Pro touchpanels
 - 2) Provide remote monitoring and control via Ethernet
 - 3) Provide the ability to create E-mail notifications
 - 4) Provide multiple levels of password protection
 - 5) Provide the ability to create schedules and monitors
 - 6) Support up to 32 Ethernet-controllable devices
 - 7) Support local variables and conditional logic
 - 8) Support grouping of multiple Extron IP Link® Pro control processors to function as one when configured with Global Configurator Professional
12. Control/Remote – RS-232 and IR Pass-Through Over Shielded CATx Requirements
- a. Provide connections for device control
 - 1) Two 5-pole captive screw: RS-232 or IR pass-through to DTP twisted pair transmitters
 - 2) Two 5-pole captive screw: RS-232 or IR pass-through to DTP twisted pair receivers
 - b. Support RS-232 and IR transmission over shielded CATx up to 330 feet (100 meters)
13. Control/Remote – Matrix Switcher Requirements
- a. Provide connections for remote matrix switcher control
 - 1) RJ-45: 10/100Base-T Ethernet

- 2) 3-pole captive screw: RS-232
 - 3) Mini USB-B: USB 2.0
 - b. Provide alternatives for configuration and operation
 - 1) Front panel controls
 - 2) Built-in Web pages accessible using a standard Web browser via Ethernet connection
 - 3) Product configuration software connected via Ethernet or USB
 - 4) Serial commands sent over Ethernet, RS-232, or USB connection
 - c. Support disabling of front panel controls to prevent inadvertent or unauthorized changes to configuration settings
- 14. General Requirements
 - a. Provide real-time verification of signal flow and operation from DTP transmitter or DTP receiver
 - b. Directly readable on RJ-45 signal and link LEDs
 - c. Shall be compatible with all Extron DTP Series models, DTP-enabled products, and Extron XTP CrossPoint matrix switchers
 - d. Shall be compatible with CATx shielded twisted pair cable, and Extron XTP DTP 24 shielded twisted pair cable
 - e. Shall provide remote power to two DTP transmitters and two DTP receivers over the shielded CATx connections
 - f. Shall provide power to external peripheral devices on each HDMI output
 - g. Enclosure shall be rack-mountable, full rack width, and 2RU in height
 - h. Shall be equipped with an internal 100-240 VAC, 50/60 Hz universal power supply

2.8 6-INPUT HDMI SWITCHER

- A. Basis of Design: Extron SW6 HDMI, part number 60-841-03
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide switching of digital video and embedded digital audio signals that shall support six inputs and one output.
 - a. Switcher for HDMI and embedded digital audio.
 - 1) Support for local device connection.
 - 2) Supports HDTV 1080p/60 and computer-video resolutions to 1920x1200.
 - 3) Supports HDMI specifications including data rates to 6.75 Gbps, Deep Color (12-bits), and HD Lossless Audio.
 - 4) Provide automatic input cable equalization to 50 feet (15.2 meters) at 1080p @ 60 Hz with 8-bit color.
 - 5) Provide +5 VDC, 250 mA power on the output.
 - 6) The device shall be HDCP compliant.
 - 7) Provide automatic management of color bit depth based on the capabilities of the connected display, as reported by the display's EDID.
 - 8) Provide automatic reformatting of HDMI source signals when routed to a DVI display.

- 9) Provide automatic EDID management between connected devices.
- 10) Shall provide user-selection of EDID from the connected display.
- 11) Shall provide user-selection of EDID from pre-stored data files.
- 12) Shall maintain continuous EDID communication with the connected sources.
- 13) Provide front panel indicators for EDID status, HDCP authentication, and signal presence.
- 14) Front panel shall provide physical buttons for creating ties within the switcher.
- 15) Provide automatic switching that follows the most recently connected or highest-numbered input with an active connected source.
- 16) Provide one RS-232 serial control port.
- 17) Device shall be housed in a 1 RU, full EIA rack-width metal enclosure
- 18) Device shall be equipped with an internal, universal AC power supply capable of supporting 100 - 240 VAC, 50/60 Hz power.

2.9 AUDIO AMPLIFIER

- A. Basis of Design: Extron XPA 2001 – 70V, part number 60-850-01
- B. Approved Equals: Brand Specific
- C. Specifications:
 1. Provide a compact, energy efficient audio amplifier that shall support one analog stereo input or two mono inputs, and one mono amplified output with 200 watts rms power output into a 70 volt line.
 2. Compact mono amplifier with 200 watts rms power output into a 70 volt line and ENERGY STAR® qualification
 - a. Input Requirements
 - 1) Shall support one stereo or two mono, balanced or unbalanced signals on one 5-pole, 3.5 mm captive screw connector.
 - 2) Shall actively sum incoming left and right channels for mono amplification.
 - b. Output Requirements
 - 1) Shall support one high impedance stereo speaker level signal on one 2-pole, 5 mm screw-lock captive screw connector.
 - 2) Shall provide a total of 200 watts rms output power into a 70 volt line measured at 1 kHz with less than 0.1% THD.
 - 3) Shall provide a signal-to-noise ratio of 100 dB measured from 20 Hz to 20 kHz, unweighted.
 - 4) Shall support a minimum load impedance of 25 ohms.
 - 5) Shall provide a THD+N measurement of less than 0.1% measured at 1 kHz and 3 dB below clipping.
 - 6) Shall provide damping factor of greater than 100 at 25 ohms.
 - 7) Shall provide a switch-selectable high pass filter for frequencies below 80 Hz with a 12 dB per octave rolloff.
 - c. Amplifier Requirements
 - 1) Shall utilize an efficient Class D amplifier design.
 - 2) Shall provide Class D Ripple Suppression technology.

- 3) Shall be convection cooled and operate without fans or vents.
- 4) Shall provide an automatic clip limiter to detect onset of clipping by comparing input and output waveforms and automatically reduce gain without audible artifacts to eliminate clipping distortion.
- 5) Shall provide multiple protection circuits that activate during output shorts, thermal overload, or DC faults.
- 6) Shall provide power factor correction technology to remove harmonic content on the AC power line.
- d. Power Requirements
 - 1) Shall draw 45 watts during typical (1/8 power) operation.
 - 2) Shall draw 12 watts during quiescent operation.
 - 3) Shall provide a low power standby mode.
 - a) Shall enter standby mode after 25 minutes (+/- 5 minutes) of inactivity.
 - b) Shall provide low power draw of less than 1 watt while in standby mode.
 - c) Shall return to full power status in less than one second upon signal detection while in standby mode.
 - d) Shall feature an input signal detection threshold of -40 dBu, +/- 3 dB on a balanced input to deactivate standby mode
 - 4) Shall be ENERGY STAR qualified.
 - 5) Shall provide internal universal power supply with IEC power socket and support for international 100-240 VAC, 50/60 Hz standards.
- e. Control Requirements
 - 1) Shall support remote control of volume and muting on 5-pole, 3.5 mm captive screw connector using optional Extron analog volume and mute controllers.
 - 2) Shall support remote standby control on 5-pole, 3.5 mm captive screw connector.
- f. Front Panel Requirements
 - 1) Shall provide an LED for power indication that lights green when the unit is receiving power and active, and lights amber when the unit is in standby mode.
 - 2) Shall provide an LED for indication of the enclosure temperature exceeding the optimal value.
 - 3) Shall provide a green LED for input signal presence indication.
 - 4) Shall provide a red LED for indication of clip warning and protection circuit activation
- g. Rear Panel Requirements
 - 1) Shall provide one input on one 5-pole, 3.5 mm captive screw connector.
 - 2) Shall provide one output on one 2-pole, 5 mm screw-lock captive screw connector.
 - 3) Shall support 22 AWG to 12 AWG speaker cables.
 - 4) Shall provide remote volume, mute, and standby control port on one 5-pole, 3.5 mm captive screw connector.
 - 5) Shall provide a recessed, detented potentiometer for attenuation adjustment.
 - 6) Shall provide a switch for selecting a high pass filter to roll off frequencies below 80 Hz.
 - 7) Shall provide a green LED for input signal presence indication.

- 8) Shall provide a red LED for indication of clip warning and protection circuit activation.
- h. General Requirements
- i. Shall be enclosed in a rack-mountable 1U, half rack width metal enclosure.

2.10 CABLE CUBBY

- A. Basis of Design: Extron Cable Cubby 700
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a modular, configurable, and furniture-mountable enclosure that shall support a combination of AC power modules, cables, and cable retraction modules
 - 2. Device shall support one AC power module plus
 - a. Up to eight cables, or
 - b. Up to four connectivity plates, or
 - c. Up to six cable retraction modules
 - 3. If AC power is not required, the device shall then support
 - a. Up to sixteen cables, or
 - b. Up to nine connectivity plates, or
 - c. Up to six cable retraction modules, plus up to eight cables or three connectivity plates
 - 4. The device shall include modules and mounting frames to support AC or AC-plus-USB power, cables and/or connectivity plates.
 - a. The modules shall be position able within the enclosure, with no fewer than three installer-determined height positions
 - b. The modules shall be position able within the enclosure, mounting to the left or right of an installed AC power module or supplemental connectivity module
 - c. AC power modules shall be available for all world markets
 - 1) AC power modules shall be UL listed and CE compliant when installed within the enclosure
 - 2) AC power modules shall include one or two AC power outlets, depending on the size of the AC outlet
 - 3) AC power modules shall include an attached AC power cord or IEC power inlet with detachable AC power cord, as required by local electrical power codes and conventions
 - d. The external power supply shall be designed and manufactured by the same entity providing the enclosure and power module
 - e. The cable pass-through plate shall be a single unit
 - 1) The plate shall be flexible to allow the installation, removal, or replacement of cables
 - 2) The plate shall utilize a split-ring design that accommodates a range of cable diameters without the need for supplemental grommets
 - 3) The plate shall include plugs to cap cable pass-through openings that are not utilized
 - 4) The assembled plate, with cables, shall install from the top of the enclosure, after it's installed within the furniture surface

- f. The connectivity frame shall be a single unit
 - 1) The frame shall support two single-space connectivity plates, or one double-space connectivity plate
 - 2) The assembled frame, with connectivity plates and attached cables, shall install from the top of the enclosure, after it's installed within the furniture surface
- g. Device shall include an attached and fully integrated, all metal lid and bezel assembly
 - 1) The lid and bezel assembly shall be available in a black anodized or brushed aluminum finish
 - 2) Device lid shall fit entirely within the bezel
 - a) When closed, the lid shall provide a full-width opening for cable pass-through
 - b) When open, the lid shall articulate such that it fits within the enclosure body
 - c) Device shall include a damper that controls the speed of the lid as it moves within the enclosure
- h. Device enclosure shall mount entirely within an opening sufficient to accommodate the enclosure
 - 1) An installation routing template, of an appropriate size to accommodate the enclosure, shall be available optionally
 - 2) The enclosure shall feature an integrated clamp system
 - a) The clamps shall be permanently affixed to the enclosure body
 - b) The clamps shall utilize a lever-and-cam mechanism
 - c) The clamps shall secure the enclosure to the furniture without the need for tools or additional parts
 - d) The clamps shall allow for removal of the enclosure from the furniture without the need for specialized tools
- i. An Internet-accessible application for enclosure configuration and visualization shall be available
 - 1) Application shall provide for selection of the enclosure, AC power modules, cables, connectivity plates, and cable retraction modules
 - 2) Application shall provide accurate depiction of power and connectivity selections
 - 3) Application shall provide a method of sing a representation of the configured enclosure and corresponding bill of materials
 - 4) Application shall provide market-specific pricing of the configured enclosure for budgetary purposes

2.11 TOUCH SCREEN CABLE CUBBY

- A. Basis of Design: Extron TLP Pro 720C, part number 60-1396-020A
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a 7" flip-up touchscreen interface for switching and control of equipment
 - 2. Furniture-mountable 7" flip-up touchscreen user interface for and control systems

- a. Provide a 7" flip-up color touchscreen that supports up to 256k colors and 800x480 resolution
 - b. Device shall support Extron IP Link Pro Control Processors
 - c. Provide built-in speaker located in the center of the cable cubby portion of the touch panel which can be configured to provide button feedback
 - d. Device shall have a female RJ-45 jack located on the back of the enclosure that supports 10/100Base-T, half/full duplex with auto-detect for connection to a LAN or WAN and includes link and activity LED indicators located on the left and right of the jack for troubleshooting network issues as well as supports PoE- Power over Ethernet, 802.3af
 - e. Device shall support the following protocols: DHCP, DNS, HTTP, HTTPS, ICMP, SFTP, SMTP, SSH, TCP/IP, UDP/IP
 - f. Provide a light sensor located on the top bezel of the touchpanels that automatically adjusts the LCD screen's backlight based on available ambient light
 - g. Provide a front panel network status LED that blinks red if the touch panel loses network connectivity with the control processor
 - h. Device shall have a menu button located under the on the front bezel of the touch panel for setup of items such as IP address and sound volume at minimum
 - i. Device shall have the following memory available, at minimum:
 - 1) SDRAM
 - a) 512 MB
 - 2) Flash
 - a) 512 MB
 - j. Device shall have an optional 12 volt captive screw connection located on the bottom of the enclosure should PoE not be available
 - k. Device shall include a multi-function button that allows for the reset of the device or its communication properties at minimum
 - l. Device shall have the ability to be controlled by an Apple iPad as a secondary point of control
 - m. Device shall have a top surface black in color
 - n. Device shall provide an integrated lid switch which can be configured to automatically wake the touch panel when open and can trigger any other system functions
 - o. Device shall include a cable cubby design for , data, and power connections
 - 1) Device shall support cable retraction systems
 - 2) Device shall support AAP's – Architectural Adapter Plates
 - p. Device shall provide LED lighting located which illuminates the cable cubby portion of the panel
 - q. Device shall support power modules from the US, Europe, and other world markets
 - r. Device shall include two US AC power outlets located within the cable cubby portion of the touch panel
3. Mounting requirements
- a. Device shall have the ability to be mounted in a flat surface such table or other piece of furniture
4. Software requirements
- a. User interface shall be created using Extron's GUI Designer software
 - b. Panel may be configured using Extron's Global Configurator Plus or Pro.

2.12 TOUCH SCREEN WALL MOUNT

- A. Basis of Design: Extron TLP Pro 720M, part number 60-1394-02
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a 7" touchscreen interface for switching and control of equipment
 - 2. Wall-mountable 7" touchscreen user interface for and control systems
 - a. Provide a 7" color touchscreen that supports up to 256k colors and 800x480 resolution
 - b. Device shall support Extron IP Link Pro Control Processors
 - c. Provide built-in speaker located in the center of the cable cubby portion of the touch panel which can be configured to provide button feedback
 - d. Device shall be a female RJ-45 jack located on the back of the enclosure that supports 10/100Base-T, half/full duplex with auto-detect for connection to a LAN or WAN and includes link and activity LED indicators located on the left and right of the jack for troubleshooting network issues as well as supports PoE- Power over Ethernet, 802.3af
 - e. Device shall support the following protocols: DHCP, DNS, HTTP, HTTPS, ICMP, SFTP, SMTP, SSH, TCP/IP, UDP/IP
 - f. Provide a light sensor located on the top bezel of the touchpanels that automatically adjusts the LCD screen's backlight based on available ambient light
 - g. Provide a front panel network status LED that blinks red if the touch panel loses network connectivity with the control processor
 - h. Device shall be a menu button located under the on the front bezel of the touch panel for setup of items such as IP address and sound volume at minimum
 - i. Device shall be the following memory available, at minimum:
 - 1) SDRAM
 - a) 512 MB
 - 2) Flash
 - a) 512 MB
 - j. Device shall be an optional 12 volt captive screw connection located on the bottom of the enclosure should PoE not be available
 - k. Device shall include a multi-function button that allows for the reset of the device or its communication properties at minimum
 - l. Device shall be the ability to controlled by an Apple iPad as a secondary point of control
 - m. Device shall be a top surface black in color
 - 3. Mounting requirements
 - a. Device shall be the ability to be mounted in a wall, lectern, or other flat surface and shall be able to be secured using the built-in four locking arms located on the top and bottom of the panel respectively or by using an optional back box.
 - b. Device shall be the ability to be mounted to the surface of a wall using an optional wall box.
 - c. Device shall be the ability to be mounted into a rack using an optional rack mount kit.

4. Software requirements
 - a. User interface shall be created using Extron's GUI Designer software
 - b. Panel may be configured using Extron's Global Configurator Plus or Pro.

2.13 MEDIA CONTROLLER

- A. Basis of Design: Extron MLC 55 RS, part number 60-1390-03
- B. Approved Equals: Brand Specific
- C. Specifications:
 1. Provide a button panel controller for switching and control of equipment
 2. Mount button panel controller for and control systems
 - a. Device shall be a total of six dual color LED backlit buttons, four dedicated for input selection and the remaining two dedicated for power arranged in a logical order
 - 1) Buttons shall illuminate white or red, depending on function, for ease of use in low-light environments.
 - 2) Buttons shall feature removable button caps allowing them to be custom labeled for easy identification.
 - b. Device shall support the creation of IR drivers by capturing IR commands from handheld remotes. IR receiver shall be located behind the faceplate.
 - c. Device shall feature a mini female USB B Port that shall be located behind the faceplate that shall allow for device configuration.
 - d. Device shall be one shared IR/Serial port on captive screw connector located on the back of the controller. This port shall allow the transmission of IR signals (using an IR emitter) and unidirectional RS-232 communications for universal display control and control of other system components.
 - e. Device shall be a 12 volt captive screw connection located on the back of the panel that will be used to power the panel using an included universal power supply.
 - f. Device shall be Section 508 Compliant and shall meet or exceed accessibility standards for Electronic Information Technology.
 - g. Device shall include a white magnetically-attached faceplate.
 - h. Device shall ship with a Button Label Sheet that can be used if button text customization is desired.
 3. Mounting requirements
 - a. Device shall be the ability to be mounted directly in a wall, lectern, or other flat surface.
 4. Software requirements
 - a. Device shall be configured using MLC 55, 62 and 64 Series Configuration software.

2.14 SIGNAL EXTENDER - RECEIVER

- A. Basis of Design: Extron DTP HDMI 4K 230 Rx, part number 60-1271-13
- B. Approved Equals: Brand Specific

C. Specifications:

1. Provide an HDMI twisted pair receiver that shall support the distribution of video, audio, and control over a shielded CATx cable
2. Rack-mountable receiver for HDMI, audio, and control
3. Video output requirements
 - a. Provide one (1) video output for digital video signals
 - 1) Supported HDMI specifications include data rates up to 10.2 Gbps, Deep Color up to 12-bit, 3D, HD lossless audio formats, and CEC pass-through
4. Audio output requirements
 - a. Support embedded digital audio on HDMI output
 - b. Provide a dedicated analog audio output connection
 - 1) One (1) stereo analog audio
5. Control output requirements
 - a. Provide communication connections for device control
 - 1) One bidirectional RS-232 pass-through
 - 2) One bidirectional IR pass-through
6. Interconnection requirements
 - a. Support interconnection between receiver and transmitter or DTP™-enabled products
 - 1) One RJ-45 twisted pair connection
7. Transmission requirements
 - a. Provide signal transmission distance capability of 230 feet (70 m) at 1920x1200, including 1080p @ 60 Hz and 2K using a shielded CATx cable
 - b. Support signal transmission distance capability of 4K @ 30 Hz, UHD, and 2560x1600 up to 130 feet (40 m) using a shielded CATx cable
 - c. Support video, audio, and control over a single shielded CATx cable
 - d. Support embedded HD lossless audio formats
 - e. Actively buffer DDC channels
8. Resolution requirements
 - a. Support computer and video resolutions up to 4K, including 1080p/60 Deep Color
 - b. Support RGB and YCbCr digital video formats
9. Audio requirements
 - a. The unit shall support analog stereo audio pass-through signals
 - b. The unit shall support multiple embedded audio formats
 - c. The unit shall support embedded HD lossless audio formats
10. HDCP requirements
 - a. The unit shall be HDCP compliant
11. Communication requirements
 - a. The unit shall support bidirectional RS-232 communication pass-through up to 115200 baud
 - b. The unit shall support bidirectional IR pass-through
 - c. The unit shall support EDID and HDCP transmission
12. Power requirements
 - a. The unit shall support remote power capability
 - b. The unit shall support being locally powered
13. General requirements
 - a. The unit shall be HDCP compliant

- b. The unit shall be compatible with CATx shielded twisted pair cable, and Extron XTP DTP 24 shielded twisted pair cable
- c. The unit shall support HDMI specifications including data rates up to 10.2 Gbps, Deep Color, 3D, HD lossless audio formats, and CEC pass-through
- d. The unit shall support being locally or remotely powered
- e. The unit shall support embedded HD lossless audio formats
- f. The unit shall support the use of HDMI to DVI-D cables or adapters for DVI-D
- g. The unit shall have a low profile enclosure and versatile mounting capability
- h. Shall provide visual indication for signal presence and power

2.15 SIGNAL EXTENDER - TRANSMITTER

- A. Basis of Design: Extron DTP HDMI 4K 230 Tx, part number 60-1271-12
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide an HDMI twisted pair transmitter that shall support the distribution of video, audio, and control over a shielded CATx cable
 - 2. Rack-mountable transmitter for HDMI, audio, and control
 - 3. Video output requirements
 - a. Provide one (1) video output for digital video signals
 - 1) Supported HDMI specifications include data rates up to 10.2 Gbps, Deep Color up to 12-bit, 3D, HD lossless audio formats, and CEC pass-through
 - 4. Audio output requirements
 - a. Support embedded digital audio on HDMI output
 - b. Provide a dedicated analog audio output connection
 - 1) One (1) stereo analog audio
 - 5. Control output requirements
 - a. Provide communication connections for device control
 - 1) One bidirectional RS-232 pass-through
 - 2) One bidirectional IR pass-through
 - 6. Interconnection requirements
 - a. Support interconnection between receiver and transmitter or DTP™-enabled products
 - 1) One RJ-45 twisted pair connection
 - 7. Transmission requirements
 - a. Provide signal transmission distance capability of 230 feet (70 m) at 1920x1200, including 1080p @ 60 Hz and 2K using a shielded CATx cable
 - b. Support signal transmission distance capability of 4K @ 30 Hz, UHD, and 2560x1600 up to 130 feet (40 m) using a shielded CATx cable
 - c. Support video, audio, and control over a single shielded CATx cable
 - d. Support embedded HD lossless audio formats
 - e. Actively buffer DDC channels
 - 8. Resolution requirements
 - a. Support computer and video resolutions up to 4K, including 1080p/60 Deep Color

- b. Support RGB and YCbCr digital video formats
- 9. Audio requirements
 - a. The unit shall accept additional analog stereo audio signals for simultaneous transmission with HDMI embedded audio
 - b. The unit shall support multiple embedded audio formats
 - c. The unit shall support embedded HD lossless audio formats
- 10. HDCP requirements
 - a. The unit shall be HDCP 2.2 compliant with backward compatibility with earlier HDCP versions
- 11. Communication requirements
 - a. The unit shall support bidirectional RS-232 communication pass-through up to 115200 baud
 - b. The unit shall support bidirectional IR pass-through
 - c. The unit shall support EDID and HDCP transmission
- 12. Power requirements
 - a. The unit shall support remote power capability
 - b. The unit shall support being locally powered
- 13. General requirements
 - a. The unit shall be HDCP compliant
 - b. The unit shall be compatible with CATx shielded twisted pair cable, and Extron XTP DTP 24 shielded twisted pair cable
 - c. The unit shall support HDMI specifications including data rates up to 10.2 Gbps, Deep Color, 3D, HD lossless audio formats, and CEC pass-through
 - d. The unit shall support being locally or remotely powered
 - e. The unit shall support embedded HD lossless audio formats
 - f. The unit shall support the use of HDMI to DVI-D cables or adapters for DVI-D.
 - g. The unit shall have a low profile enclosure and versatile mounting capability
 - h. Shall provide visual indication for signal presence and power

2.16 TWO INPUT DTP TRANSMITTER

- A. Basis of Design: Extron DTP T USW 233, part number 60-1329-12
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a two input decorator-style wall plate twisted pair transmitter that shall support the distribution of video, audio, and control over a shielded CATx cable.
 - 2. Two-gang decorator-style wall plate transmitter for the transmission of HDMI, VGA, audio, and control.
 - a. Video Input Requirements
 - 1) Provide one (1) HDMI input for digital video signals:
 - a) Supported HDMI specifications include 1080p/60, 2K, data rates up to 6.75 Gbps, 3D, and HD lossless audio formats
 - 2) Provide one (1) HD-15 input for VGA signals
 - a) Shall digitize analog video input signals prior to transmission to the digital video output

- b) Support computer and video resolutions up to 1920x1200, including 1080p/60
- b. Switching Requirements
 - 1) Provide automatic switching between input sources
 - a) Automatically switch to the highest-numbered input with an active video signal when multiple inputs are active
 - 2) Shall support RS-232 control
 - 3) Shall support contact closure control
- c. Audio input requirements
 - 1) Support embedded digital audio on HDMI input
 - 2) Provide dedicated analog audio input connections
 - a) Two (2) stereo analog audio
 - 3) Support embedding of the analog audio input signals on the digital video output signal and transport over DTP
- d. Control input requirements
 - 1) Provide communication connections for device control
 - a) One bidirectional RS-232 pass-through
 - b) One unidirectional IR pass-through
 - 2) The transmitter shall be RS-232 controllable
 - 3) The transmitter shall support input switching via contact closure
- e. Interconnection requirements
 - 1) Support interconnection between transmitter and receiver or DTP®-enabled products
 - a) One RJ-45 twisted pair connection
- f. Transmission requirements
 - 1) Provide a signal transmission distance capability of 230 feet (70 m) at 1920x1200, including 1080p @ 60 Hz and 2K using a shielded CATx cable
 - 2) Support video, digitized analog video, audio, and control over a single shielded CATx cable
 - 3) Support embedded HD lossless audio formats
 - 4) Support embedded analog audio
 - 5) Actively buffer DDC channels
- g. Resolution requirements
 - 1) Support computer and video resolutions up to 1920x1200, including 1080p/60 and 2K
 - 2) Support RGB and YCbCr color space formats
- h. Audio requirements
 - 1) The unit shall accept additional analog stereo audio signals
 - 2) The unit shall support multiple embedded audio formats
 - 3) The unit shall support embedded HD lossless audio formats
 - 4) The unit shall support embedding analog stereo audio signals onto the digital video output signal and transport over DTP
- i. EDID requirements
 - 1) Provide automatic EDID management between connected devices
 - a) Shall provide user-selection of EDID from any connected display
 - b) Shall provide user-selection of EDID from pre-stored data files
 - c) Shall maintain continuous EDID communication with the connected source
- j. HDCP requirements
 - 1) The unit shall be HDCP compliant

- 2) Shall provide the option to disable HDCP processing at the HDMI input connection when passing unencrypted content
- k. Communication requirements
 - 1) The unit shall support bidirectional RS-232 communication pass-through up to 115200 baud
 - 2) The unit shall support unidirectional IR pass-through
 - 3) The unit shall support EDID and HDCP transmission
- l. Power requirements
 - 1) The unit shall support remote power capability
 - 2) The unit shall support being locally powered
- m. Control/Configuration requirements
 - 1) Shall support auto-switching between inputs
 - 2) Shall support RS-232 control
 - 3) Shall support contact closure for input selection
 - 4) Shall support product configuration/setup through a product configuration software application connected via USB
- n. General requirements
 - 1) The unit shall be HDCP compliant
 - 2) The unit shall be compatible with CATx shielded twisted pair cable, and Extron XTP DTP 24 shielded twisted pair cable
 - 3) The unit shall support HDMI specifications including data rates up to 6.75 Gbps, 3D, and HD lossless audio formats
 - 4) The unit shall support being locally or remotely powered
 - 5) The unit shall support embedded HD lossless audio formats
 - 6) The unit shall support the use of HDMI to DVI-D cables or adapters for DVI-D signals
 - 7) The unit shall support installation into standard two-gang electrical junction boxes
 - 8) Shall provide visual indication for signal presence and power
 - 9) Shall meet regulatory compliances
 - a) CE, c-UL, UL
 - b) CE, C-tick, FCC Class A, ICES, VCCI
 - 10) Shall provide at least 3 years parts and labor warranty
 - 11) Shall be compatible with other DTP-enabled products

2.17 SHARELINK

- A. Basis of Design: Extron ShareLink 200, part number 60-1508-01
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Shall provide a wireless connection for personal devices to enable BYOD content presentation on a shared display or displays
 - 2. Wireless content sharing from Microsoft Windows® and OS X® computers as well as Apple® and Android® smartphones, and tablets
 - 3. Digital video output requirements
 - a. Shall provide one (1) HDMI Type A connector for digital video signals with embedded audio

- b. Shall support 720p, 1080i, and 1080p resolutions
- 4. Analog video output requirements
 - a. Shall provide one (1) 15-pin HD connector for analog video signals
 - b. Shall support output resolutions: UXGA(1600x1200), WXGA+(1440x900), WXGA(1360x768, 1280x768, 1280x800), XGA(1024x768), and SVGA(800x600)
- 5. Audio output requirements
 - a. Shall support embedded audio on HDMI output connector
 - b. Shall provide one (1) 3.5 mm stereo audio mini jack for analog stereo audio signals
- 6. Peripheral interconnection requirements
 - a. Shall provide three USB connections for peripheral support, content playback from a USB mass storage device, and to enable simple annotation capabilities with interactive whiteboards and other such devices
 - b. Two USB connectors on the front panel
 - c. One USB connector on the back panel
- 7. Network interconnection requirements
 - a. Shall provide an integrated wireless access point
 - b. Shall provide two antennas for wireless transmission
 - c. Shall provide a Gigabit Ethernet connection to support a high-speed data link to networks and other network resources
 - d. Shall provide SNMP support to allow remote health monitoring of network-attached devices
 - e. Shall provide network control of image playback for visual alerts or administrative announcements
- 8. Control requirements
 - a. Shall support remote access via a web browser for setup and configuration
 - b. Shall provide a collaboration mode that enables any attendee to display content from a personal device and control the presentation
 - c. Shall provide a moderator mode for single-point control to ensure only approved content is displayed
 - d. Shall support use of security codes to authenticate users and prevent unintentional display of content within adjacent spaces
 - 1) Randomly generated authentication codes
 - 2) User-defined authentication codes
 - e. Shall support USB HID devices, such as a keyboard, mouse, or touch panel, for control via the OSD menu:
 - 1) Playback from a USB flash drive
 - 2) Use the display as a whiteboard
 - 3) Resize the screen
 - 4) Calibrate touch point coordinates
 - f. Functional requirements
 - 1) Shall provide screen display of content from a single personal device or simultaneous display of multiple devices into four windows on a single display
 - 2) Shall enable presentation of content from an Apple® iOS® or Android® smartphone or tablet via a wireless network connection MirrorOp® for Extron ShareLink app
 - 3) Shall enable presentation of content from a Windows® or Apple® OS-X® computer via a wireless or wired network connection

- 4) Shall provide content sharing from a Windows or Apple OS X computer to as many as four ShareLink 200 units on the network, supporting up to four display devices
- 5) Shall enable the presentation of Word, Excel, PowerPoint, PDF, and still images from any supported device
- 6) Shall provide full motion playback of video and audio from Windows or OS X computers
- 7) Shall support full motion playback of video and audio from a USB mass storage device
- 8) Shall provide an on-screen display – OSD menu for content presentation from a USB mass storage device
- 9) Shall provide WebShare technology to enable attendees to view slide images on personal devices via a wireless connection and a Web browser
- g. Power requirements
 - 1) Shall provide connection for 5 VDC power on one coaxial connector
 - 2) Shall be equipped with an external, universal AC power supply capable of supporting 100 - 240 VAC, 50/60 Hz power
 - 3) Shall be PoE IEEE 802.3at, class 20 (type I), Power over Ethernet compliant
- h. General requirements
 - 1) Shall support the use of HDMI to DVI-D cables or adapters for DVI-D signals
 - 2) Shall provide an LED indicator on the front panel for visual indication of power
 - 3) Shall be a 1" (2.5 cm) high, three-eighths rack width metal enclosure
 - 4) Shall have two front-mounted antennas that pivot
 - 5) Shall be rack mountable with optional rack shelf
 - 6) Shall be furniture or wall mountable with optional mounting kits
 - 7) Shall meet regulatory compliance

2.18 AUDIO MANAGER

A. Basis of Design: Extron DMP 128 C, part number 60-1178-01

B. Approved Equals: Brand Specific

C. Specifications:

1. Provide an audio digital signal processor that shall support 12 mono analog inputs capable of microphone or line level signals and eight mono analog line level outputs for signal routing and management.
2. 12 input, eight output audio digital signal processor with acoustic echo cancellation, digital audio expansion port, automixer function with eight groups, 64-bit floating point DSP engine, and 24-bit/48 kHz audio converters
3. Input Requirements
 - a. Shall support eight mono, microphone or line level, balanced or unbalanced signals on eight 3-pole, 3.5 mm captive screw connectors
 - b. Shall support four mono, microphone or line level, balanced or unbalanced signals on two 6-pole, 3.5 mm captive screw connectors

- c. Shall provide input gain adjustment from -18 dB to +80 dB in 0.1 dB steps, adjustable per input
 - d. Shall provide selectable +48 volt phantom power for condenser microphones on first eight inputs
 - e. Shall provide analog to digital conversion at 48 kHz sampling rate with 24-bit resolution
- 4. Output Requirements
 - a. Shall support eight mono line level, balanced or unbalanced signals on four 6-pole, 3.5 mm captive screw connectors
 - b. Shall provide output attenuation adjustment from 0 dB to -100 dB in 0.1 dB steps, adjustable per output
 - c. Shall provide digital to analog conversion at 48 kHz sampling rate with 24-bit resolution
- 5. DSP Engine Requirements
 - a. Shall provide 64-bit floating point DSP engine
 - b. Shall support 32-bit and 64-bit processing algorithms depending on process
 - c. Shall provide a maximum, deterministic latency 9.9 ms from input to output on inputs 1 through 8
 - d. Shall provide a maximum, deterministic latency of 4.5 ms from input to output 9 through 12
 - e. Shall provide additional, deterministic latency of 2 ms when Virtual Path routing is used
 - f. Shall provide additional, deterministic latency of 4 ms when Automixing is used
 - g. Shall provide additional, deterministic latency of 16 ms when AEC is used
- 6. Audio Device Requirements — Input to Output
 - a. Shall provide a signal-to-noise ratio of greater than 105 dB measured from 20 Hz to 20 kHz, at maximum balanced output, unweighted
 - b. Shall provide a THD+N measurement of less than 0.01% measured at 20 Hz to 20 kHz, at maximum level
- 7. Configuration Software Requirements
 - a. Shall provide PC-based DSP Configurator software allowing flexible control of the digital signal processor's fixed architecture
 - b. Shall provide a Live mode for real-time control of parameters without compiling and file uploading to processor
 - c. Shall provide an Emulate mode for offline configuration
 - d. Shall provide single window view of all inputs and outputs, audio processing blocks, routing, mix points, and virtual routing
 - e. Shall provide setup and configuration of digital audio processing tools including, but not limited to: Filters (high pass, low pass, bass, treble and parametric EQ); AEC; Dynamics processing (AGC, compressor, limiter, noise gate); Delay processing; Ducking processor; Automixing; Loudness processor; and multiple gain stages
 - f. Shall provide cut and paste editing between processing blocks
 - g. Shall provide matrix routing with integrated mix point gain adjustment between inputs, outputs, virtual sends, virtual returns, expansion inputs, and expansion outputs
 - h. Shall provide a library of pre-designed processor settings for inputs and outputs with user-customizable parameters

- i. Shall provide 32 Group Master controls for consolidation of up to 16 individual gain or mute control members of the same type into one point of control
 - j. Shall provide Soft Limits settings to define upper and lower control limits on Group Masters for use with external controls
 - k. Shall provide 32 Presets for recall of any processing block setting, level setting or audio routing; presets shall be set for the entire system, or any selected partial group of inputs, outputs, mix points, and DSP blocks
 - l. Shall provide real-time metering of levels within each Input Gain, AEC, AGC, Compressor, Limiter, Noise Gate, Automixer, and Output Volume processing block in Live mode
 - m. Shall provide a Meter Bridge window for real-time metering of all input and output channels with clipping indication in Live mode
 - n. Shall provide keyboard-based navigation of configuration software utilizing directional controls, keyboard shortcuts, and spreadsheet software-style commands
 - o. Shall provide file saving in both Live and Emulate mode
 - p. Shall provide file upload in both Live and Emulate mode
 - q. Shall provide configuration and file saving of multiple, linked or networked processors from a single configuration software session
8. Expansion Port Requirements
- a. Shall provide digital audio expansion port for bidirectional signal routing between two connected processors
 - b. Shall support 16 incoming signals and 16 outgoing signals
 - c. Shall provide uncompressed digital audio at 48 kHz sampling rate with 24-bit resolution
 - d. Product shall include as standard, 1 foot (0.3 m) shielded CAT 6 cable for the purposes of interconnecting two units
9. Automixer Requirements
- a. Shall provide Automixer Group selection for optional channel assignment into any of eight groups
 - b. Shall provide gated and gain sharing automixer types
 - c. Shall provide Last Mic Open Priority and Chairman Priority modes
 - d. Shall provide Number of Open Microphone parameter from 0 to 12 microphones
 - e. Shall provide Gate Threshold level and adjustable Off Reduction level for gated channels
 - f. Shall provide adjustable parameters for Attack, Hold, and Release times
 - g. Shall provide real-time metering of Signal Level, Gate Status, and Gate Threshold target from within the Automix parameter setup window
 - h. Shall provide global view with Gate Status indication of all channels assigned to an automixer group
10. AEC – Acoustic Echo Cancellation Processing Requirements
- a. Shall provide eight independent channels of AEC
 - b. Shall provide real-time software-based metering of Echo Return Loss, Echo Return Loss Enhancement, and Total Echo Reduction levels
 - c. Shall provide real-time indication of remote site activity, local site activity, and AEC processor reconverging
 - d. Shall provide up to 20 dB of selectable noise cancellation for each AEC channel

- e. Shall provide advanced controls and adjustable parameters for Non-Linear Processing, Double Talk Echo Reduction, and Comfort Noise for each AEC channel
 - f. Shall provide greater than 200 milliseconds of AEC tail length
 - g. Shall provide up to 60 dB per second AEC convergence rate
- 11. Control Requirements
 - a. Shall provide Ethernet monitoring and control using standard TCP/IP protocols to support real-time monitoring and system management over a LAN or WAN on RJ-45 connector
 - b. Shall support bidirectional RS-232 on 3-pole, 3.5 mm captive screw connectors
 - c. Shall support USB 2.0 control on female mini USB B connector
 - d. Shall support remote control operation via external control system using Simple Instruction Set commands sent over RS-232 on 3-pole, 3.5 mm captive screw connectors or Ethernet on RJ-45 connector
 - e. Shall provide 20 digital I/O ports on 3-pole, 3.5 mm captive screw connectors for processor remote control and/or feedback to external control system or physical devices
- 12. Front Panel Requirements
 - a. Shall provide a green LED for power indication
 - b. Shall provide Configuration port on mini USB B connector
 - c. Shall provide green LEDs for Expansion and LAN port activity indication
 - d. Shall provide green LEDs for input and output signal presence indication
 - e. Shall provide red LEDs for clip warning indication
- 13. Rear Panel Requirements
 - a. Shall provide LEDs for input channel 1 through 8 phantom power indication
 - b. Shall provide 12 inputs on 3.5 mm captive screw connectors
 - c. Shall provide eight outputs on 3.5 mm captive screw connectors
 - d. Shall provide 20 digital input/output ports on 3.5 mm captive screw connectors
 - e. Shall provide bidirectional RS-232 port on 3.5 mm captive screw connector
 - f. Shall provide Expansion port on RJ-45 connector
 - g. Shall provide Ethernet host port on RJ-45 connector
- 14. General Requirements
 - a. Shall provide internal universal power supply with IEC power socket and support for international 100-240 VAC, 50/60 Hz standards
 - b. Shall be enclosed in a rack-mountable 1U, full rack width metal enclosure
 - c. Shall be fan-cooled with right to left airflow

2.19 STEREO AMPLIFIER

- A. Basis of Design: Extron MPA 152 Plus, part number 60-844-03
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a compact, energy efficient audio power amplifier that shall support three analog stereo inputs and one amplified stereo output or two mono analog outputs with 15 watts rms per channel.

2. Compact stereo amplifier with 15 watts rms power output per channel, ENERGY STAR® qualification, and stereo or dual mono operation.
3. Input Requirements
 - a. Shall support one stereo, balanced or unbalanced signal on one 5-pole, 3.5 mm captive screw connector
 - b. Shall support one stereo, unbalanced signal on one pair of RCA connectors
 - c. Shall support one stereo, unbalanced signal on one 3.5 mm stereo mini jack
 - d. Shall provide individual buffering for each input
 - e. Shall provide stereo input summing of all inputs into a single stereo signal
 - f. Shall provide summing of left and right channels, and route the resulting mono signal to both outputs when dual mono output is selected
4. Output Requirements
 - a. Shall support one stereo speaker level signal or two mono speaker level signals on one 4-pole, 5 mm captive screw connector
 - b. Shall provide a total of 30 watts rms output power with 15 watts rms per channel into 4 ohms or 8 watts per channel into 8 ohms measured at 1 kHz with 1% THD
 - c. Shall provide a signal-to-noise ratio of 90 dB measured from 20 Hz to 20 kHz, +1/-3 dB, at 8 ohms
 - d. Shall provide a THD+N measurement of less than 0.1% measured at 1 kHz, at 8 ohms and 3 dB below clipping
 - e. Shall provide damping factor of greater than 100 at 8 ohms
5. Amplifier Requirements
 - a. Shall utilize an efficient Class D amplifier design
 - b. Shall provide Class D Ripple Suppression technology
 - c. Shall be convection cooled and operate without fans or vents
 - d. Shall provide an automatic clip limiter to detect onset of clipping by comparing input and output waveforms and automatically reduce gain without audible artifacts to eliminate clipping distortion
6. Power Requirements
 - a. Shall draw 7.3 watts during typical (1/8) power operation with both output channels driven with 4 ohm loads
 - b. In conjunction with power supply, shall draw 3.1 watts during typical (1/8 power) operation with both output channels driven with 4 ohm loads
 - c. Shall draw 3.1 watts during quiescent operation
 - d. In conjunction with power supply, shall draw 3.8 watts during quiescent operation
 - e. Shall provide a low power standby mode
 - 1) Shall enter standby mode after 25 minutes (+/- 5 minutes) of inactivity
 - 2) Shall draw less than 1 watt while in standby mode
 - 3) Shall return to full power status in less than one second upon signal detection while in standby mode
 - 4) Shall feature an input signal detection threshold of -53 dBV, +/- 3 dB on unbalanced RCA and 3.5 mm stereo mini jack inputs to deactivate standby mode
 - 5) Shall feature an input signal detection threshold of -46 dBu, +/- 3 dB on balanced captive screw connector input to deactivate standby mode
 - 6) Shall provide a defeatable auto standby timer and retain ENERGY STAR qualification
 - f. Shall be ENERGY STAR qualified

- g. Shall provide energy-efficient external universal power supply with 2-pole captive screw connector
 - 1) Shall be universal in-line power supply with IEC power socket and support for international 100-240 VAC, 50/60 Hz standards
 - 2) Shall provide output of 12 VDC, 2 A, 24 watts
 - 3) Shall support use of optional Extron ZipClip™ 200 mounting bracket
 - 4) Shall meet energy efficiency level V and bear the UL Environment Energy Efficiency Certification (EEC) Mark
- 7. Control Requirements
 - a. Shall support remote control of volume and muting on 3-pole, 3.5 mm captive screw connector using optional Extron analog volume and mute controllers
 - b. Front Panel Requirements
 - c. Shall provide an LED for power indication that lights green when the unit is receiving power and active, and lights amber when the unit is in standby mode
 - d. Shall provide a recessed switch for toggling between stereo or dual mono output modes
 - e. Shall provide potentiometers for bass, treble, and input level adjustment
- 8. Rear Panel Requirements
 - a. Shall provide one input on one 5-pole, 3.5 mm captive screw connector
 - b. Shall provide one input on one pair of RCA connectors
 - c. Shall provide one input on one 3.5 mm stereo mini jack
 - d. Shall provide one output on one 4-pole, 5 mm captive screw connector
 - e. Shall provide remote volume and mute control port on one 3-pole, 3.5 mm captive screw connector
- 9. General Requirements
 - a. Shall be enclosed in a rack-mountable 1U, quarter rack width metal enclosure

2.20 VGA TO HDMI CONVERTER

- A. Basis of Design: Extron RGB-HDMI 300 A, part number 60-1074-01
- B. Approved Equals: Brand Specific
- C. Specifications:
 - 1. Provide a video scaler that shall support one input and one output for processing and converting HDTV and RGB video sources to HDMI.
 - 2. Rack-mountable scaler for HDTV and RGB video sources and associated audio
 - a. Video Input Requirements
 - 1) One 15-pin HD, configurable for RGB or component video
 - b. Provide automatic detection of input video parameters
 - 1) Determine total pixels, active pixels, active lines, H/V starting points, H/V image positions, H/V image sizes, and video clock phase
 - 2) The user may selectively enable or disable automatic detection for the input
 - c. Provide automatic detection of analog input formats
 - 1) Automatically recognize RGBHV or component video signals without user action

- 2) Automatically apply appropriate processing parameters including video decoding and color space setting
 - d. Provide image adjustments for brightness, contrast, detail, H/V positioning, sizing, and zoom
 - e. Provide storage and recall of video parameters and picture settings
 - 1) Automatic memories for each video input
 - a) Set video settings and picture adjustments without user intervention
 - b) Automatically recall settings when the same video rate is encountered
 - c) The user may selectively enable or disable automatic memories
 - f. Manual user presets
 - 1) Set picture adjustments
 - 2) User presets may be set and recalled using front panel controls
 - 3) User presets may be set and recalled electronically via RS-232
 - g. Manual input presets
 - 1) Set video settings and picture adjustments
 - 2) Input presets may be set and recalled electronically via RS-232
- 3. Video Output Requirements
 - a. Provide video output connection
 - 1) One HDMI
 - b. Provide a range of selectable video output rates up to 1920x1200, including HDTV 1080p/60 and 2048x1080p/60
 - c. Provide aspect ratio control
 - 1) When in FILL mode, the video image shall always fill the output screen without letterbox or pillarbox
 - 2) When in FOLLOW mode, the video image on the output screen shall always preserve the aspect ratio of the input signals without distortion
 - d. Provide internal test patterns for calibration and setup
 - e. Support automatic muting of video and sync output when no video input signal is present
 - 1) Provide a choice of a blue screen or a black screen before disabling sync
 - 2) Provide a configurable timeout period before disabling sync
 - 3) The user may selectively enable or disable automatic muting of sync output
 - f. Support selection of output color space as RGB or component video
- 4. EDID Requirements
 - a. Support assignment of a user-selected EDID resolution and refresh rate for the incoming video signal
- 5. Audio Requirements
 - a. Provide audio input connection
 - 1) One 3.5 mm stereo mini jack, unbalanced analog stereo
 - b. Provide audio output connection
 - 1) One HDMI, embedded
 - c. Support embedding of the analog audio input signal onto the HDMI output
 - d. Provide a delay in the audio output to match the corresponding video processing delay
 - e. Provide gain and attenuation adjustments for analog input audio
- 6. Control Requirements
 - a. Provide control connections

- 1) 3-pole captive screw: RS-232
 - 2) 2.5 mm mini stereo jack: RS-232
 - b. Provide alternatives for configuration and operation
 - 1) On-screen menus nigated using front panel controls
 - 2) Software control program connected via RS-232
 - 3) Serial commands sent over RS-232
 - c. Support disabling of front panel controls to prevent inadvertent or unauthorized changes to configuration settings
7. General Requirements
 - a. Enclosure shall be rack-mountable, half rack width, and 1" (2.5 cm) in height
 - b. Shall be equipped with an external universal AC power supply capable of supporting 100-240 VAC, 50/60 Hz power
 - c. Shall meet regulatory compliances

2.21 USB EXTENDER

- A. Basis of Design: Extron Extender D Tx, part number 60-1252-13
Extron Extender Rx, part number 60-871-72
- B. Approved Equals: Brand Specific
- C. Specifications:
 1. Provide extension of computer peripheral devices such as human input devices, imaging devices, or storage devices, over a single CAT 5-type cable
 - a. Twisted pair extender for USB peripherals
 - 1) Provide extension of USB peripheral devices up to 450 feet (135 meters) over one CAT 5/5e/6 or CAT 7 twisted pair cable
 - 2) Extender shall support devices that comply with USB 1.0, 1.1, or 2.0 standards
 - 3) Device shall support data transfer rates up to 480 mbps
 - 4) Transmitter shall provide connection for the host computer on one USB Type B connector
 - 5) Receiver shall provide four USB Type A ports for simultaneous connection of up to four USB peripheral devices
 - a) Each receiver port shall provide 5 VDC, 500 mA power
 - 6) Transmitters and receivers shall be available in a variety of form factors that can be used interchangeably
 - a) Transmitters and receivers shall be available in a 1-inch (2.5 cm) high, one-quarter EIA rack-width metal enclosure
 - b) Transmitters and receivers shall be available in a wall-mountable enclosure that fits within a standard US one-gang electrical box
 - c) Transmitters and receivers shall be available in a furniture- or floor box-mountable enclosure
 - d) Transmitters and receivers shall work together without regard to form factor
 - 7) Transmitters and receivers shall be equipped with an external, universal AC power supply capable of supporting 100 - 240 VAC, 50/60 Hz power

2.22 WIRELESS MICS

- A. Basis of Design: Revolabs Executive HD.
- B. Approved Equals: Lectrosonics, Shure.
- C. Audio Specifications:
 - 1. Channels: 8 channels per system
 - 2. Radio Frequency: 1920 to 1930 MHz
 - 3. Range: 300 feet; Out of range alarm
 - 4. Bandwidth: 50 – 14,000 Hz
- D. Base Station Specifications:
 - 1. Power: 100-240V, 50-60 Hz, 20W
 - 2. Connectors/Interfaces: IEC Universal power connector, Channel LED indicators, Pairing Push Buttons, Configuration DIP Switches, 3.5 mm Mini Phoenix line level inputs and Line/Mic, Level outputs per channel, DB9 RS-232 serial, RJ-45 LAN, and 3.5 Mini Phoenix serial bus
 - 3. Display: High resolution LCD display
- E. Charger Base Specifications:
 - 1. Power: 24V DC, 1A
100-240V, 50-60 Hz; Power supply included
 - 2. Connector Interfaces: 8 proprietary 4-pin microphone charge jacks, USB port for firmware update only

2.23 SYSTEM SPEAKERS

- A. Basis of Design: Extron SF 26CT, part number 60-1310-03.
- B. Approved Equals: JBL, Atlas.
- C. Specifications:
 - 1. Provide a two-way closed back ceiling speaker that shall provide an internal transformer for 8 ohm direct and 70/100 volt operation
 - a. Driver Requirements
 - 1) Shall consist of a 6.5" (165 mm) long-throw, polypropylene cone woofer with moisture resistant coating
 - 2) Shall consist of a 3/4" (19.1 mm) Ferro fluid-cooled PEI dome tweeter that is mounted on a hexagonal tweeter bridge
 - b. Performance Requirements
 - 1) Shall provide a frequency range of 65 Hz to 22 kHz, -10 dB below erage SPL, measured on-axis in half space per IEC 60268-5

- 2) Shall provide a frequency response of 88 Hz to 22 kHz, +/-3 dB, measured in half space
- 3) Shall provide a power handling capacity of 65 watts (rms) continuous pink noise and 130 watts (rms) continuous program
- 4) Shall provide a nominal sensitivity of 88 dB SPL (1 W, 1 m) measured in half space
- 5) Shall provide a nominal impedance of 8 ohms per speaker
- 6) Shall provide a nominal conical coverage angle of 111° (1 kHz to 4 kHz)
- c. Electrical Requirements
 - 1) Shall support 8 ohm direct or 70/100 volt connection from power amplifiers
 - 2) Shall provide a six-position, through-the-grille power tap selector
 - a) Shall provide selectable rotary switch taps for 70 volt operation, including 64 watts, 32 watts, 16 watts, 8 watts, and 8 ohms direct
 - b) Shall provide selectable rotary switch taps for 100 volt operation, including null, 64 watts, 32 watts, 16 watts, and 8 ohms direct
 - 3) Shall provide speaker tap selector and selection guide on the front of the speaker
 - 4) Shall provide a full range power limiter with the 8 ohm direct input, protecting the tweeter, woofer, and crossover
 - 5) Shall support one incoming and one outgoing speaker level signal on one 4-pole, 5 mm captive screw connector
 - a) Shall support wiring multiple speakers using parallel or loop-through wiring
 - b) Shall support a maximum wire gauge of 12 AWG per connection point for a single wire
 - c) Shall support a maximum wire gauge of 16 AWG per connection point for two wires
- d. Speaker Enclosure Requirements
 - 1) Shall provide a thin-edged rounded bezel surrounding the grille
 - a) Shall measure 11.09" (281.7 mm) in diameter from bezel edge to edge
 - b) Shall provide a white, paintable magnetically-attached perforated steel grille with black scrim
 - 2) Shall measure 10.64" (270.3 mm) in diameter
 - 3) Shall measure 8.0" in height from front of ceiling tile to back of rear enclosure
 - 4) Shall weigh 9.4 lbs. (4.3 kg) per speaker
 - 5) Shall require 9.3" (236.2 mm) diameter opening in mounting surface for speaker cutout
- e. General Requirements
 - 1) Shall be sold in pairs
 - 2) Shall be a separable back can and baffle to support single trade and division of labor applications
 - 3) Shall include modular V-rail and folding C-ring kits
 - 4) Shall be a cable/conduit access plate that can be oriented for side or top connections
 - 5) Shall be a 5-year parts and labor warranty
 - 6) Shall be compatible with Extron SGK SF26C Square Grille Kit
 - 7) Shall meet regulatory compliances

- a) Shall meet safety compliances under CE, UL 2043, UL1480, NFPA 90A, and NFPA 70
- b) Shall be UL listed for plenum airspaces and meet UL 2043 for heat and smoke release
- c) Shall meet UL 1480 for commercial and professional audio systems
- d) Shall comply with appropriate requirements for RoHS and WEEE
- 8) Shall provide five year parts and labor warranty

2.24 RACK FANS

A. Basis of Design: Procool SX40 DC Axial Fan

B. Approved Equals: Brand Specific

C. Specifications:

1. Input Voltage	120vac, 60Hz
2. Current Capacity	12 Amps
3. Current Overload Protection	15 Amps
4. AC Line Filtration	Line Capacitor (Line & Neutral)
5. Voltage Spike Protection	Metal Oxide Varistor (Line & Neutral)
6. Power Cord	15 Amps, 6ft 16/3 SJT with NEMA 5-15P Plug
7. Power Outlet Receptacles	8 NEMA 5-15 (back), 1 NEMA 5-15 (front)
8. Dimensions	19"W x 1.75"H x 7"D
9. Weight	5.5lbs

2.25 POWER SEQUENCER/CONDITIONER

A. Basis of Design: Juice Goose SQ-1520, 20 amps

B. Approved Equals: SurgeX, Furman

C. Specifications:

1. Rated Voltage	12vDC
2. Voltage Range	8 ~ 14vDC
3. Rated Current	0.03 Amps
4. Rated Power	0.36 W
5. Rated Speed	<3200 RPM
6. Airflow	<6 CFM
7. Static Pressure	< 2.32 mm H2O
8. Noise Level, xyz axis	<13dBA
9. Noise Level, z axis	<14dBA
10. Operating Temperature	-10/+70 Degree Celsius
11. Storage Temperature	-40/+80 Degree Celsius
12. Bearing	Fluid Dynamic
13. Weight	0.08 Ounce

2.26 POWER OVER ETHERNET (POE) NETWORK SWITCH

- A. Basis of Design: HP 1920-24G-PoE+ (370W) Switch
- B. Approved Equals: Owner approved equal.
- C. Specifications:
 - 1. 24-port gigabit advanced smart managed PoE+ switch with a 370W PoE power budget and 4 GbE SFP ports
 - 2. Ports:
 - a. 24 RJ-45 auto-negotiating 10/100/1000 PoE+ ports
 - b. 4 SFP 1000 Mbps ports
 - c. Supports a maximum of 24 autosensing 10/100/1000 ports plus 4 1000BASE-XSP ports or a combination.
 - 3. Memory and Processor
 - a. MIPS @ 500 MHz
 - b. 32 MB flash
 - c. Packet buffer size: 4.1 Mb
 - d. 128 MB SDRAM
 - 4. Latency
 - a. 100 Mb Latency: < 5us
 - b. 1000 Mb Latency: < 5us
 - 5. Throughout
 - a. Up to 41.7 Mpps
 - 6. Routing/switching capacity
 - a. 56 Gps
 - 7. PoE capability
 - a. 370 W PoE+
 - 8. Dimensions:
 - a. 17.32"W x 9.37"D x 1.73"H
 - 9. Weight:
 - a. 7.5 lb

2.27 VIDEO CONFERENCE CAMERA

- A. Basis of Design: Logitech C920
- B. Approved Equals: Drop Camera, Microsoft.
- C. Specifications:
 - 1. Lens: Focal Length = 3.67mm
 - 2. Shooting Area: 78 Degree Field Of View (FOV)
 - 3. Zoom: 4X Zoom
 - 4. Focus: Auto Focus/Manual
 - 5. Iris: Auto (with fine level adjustment)
 - 6. Frame Rate: SXGA: 30 fps
 - 7. Resolution: 1920 x 1080
 - 8. USB I/F: USB 2.0 support

9.	Illumination:	LED Illumination system
10.	Input Port:	USB 2.0
11.	Output Port:	USB 2.0
12.	Power Input:	USB
13.	Dimensions:	5"W x 2.87"H x 1.77"D
14.	Weight:	6.0 Ounce

2.28 PC DESKTOP

- A. Basis of Design: N/A
- B. Specifications:
 - 1. Owner Furnished, Contractor Installed.

2.29 BLU-RAY PLAYER

- A. Basis of Design: SAMSUNG BD-H6500.
- B. Approved Equals: Sony, Panasonic.
- C. Specifications:
 - 1. Anynet + (HDMI CCEC)
 - 2. 3D capability
 - 3. Apps Platform
 - 4. BD Wise
 - 5. Audio: Dolby Digital, Dolby Digital Plus, Dolby True HD, DTS-HD Decoder, DTS Surround
 - 6. Video: HD Conversion, Quick Start Mode
 - 7. Wireless Connectivity: Wi-Fi Ready
 - 8. Input: HDMI
 - 9. Output: USB 2.0, Ethernet (RJ-45/LAN)
 - 10. Playback Formats: MPEG2/3.CHD, DTS-HD Bitstream Output, LPCM, AAC, MP3, WMA, DTS-HD Master Audio Decoding
 - 11. Playback Media: DVD-Video/DVD+R/DVD+RW, CD DA/CD-R/CD-RW, MKV, WMV, JPEG, MPO
 - 12. Dimensions: 14.17"W x 1.57"H x 7.72"D
 - 13. Weight: 1.1 lbs.

2.30 FLAT PANEL DISPLAY, 42"

- A. Basis of Design: Sharp PN-Y426, PN-ZB03W.
- B. Approved Equals: NEC, Samsung.
- C. Specifications:

1. Screen Size: 42"
2. Display Type: TFT LCD
3. Native Display Resolution: 1920 x 1080p
4. Max Brightness: 700 cd/m²
5. Contrast Ratio: 1300:1
6. Viewing Angle: 178°
7. Active Screen Area: 47-5/8" x 26-13/16"
8. Response Time: 8 ms
9. Backlight: LED, edge lit
10. Power Supply: 100V – 240V AC
11. Power Consumption: 135 W
12. Speaker Output: 10W + 10W
13. Input Terminals: DisplayPort, Mini-D, HDMI, Audio, RS-232C
14. Output Terminals: DisplayPort, Audio, RS-232C
15. Input / Output Terminals: LAN
16. Dimensions: 55-13/32"W x 3-3/8"D x 32-5/32"H
17. Weight: 34.2 lbs.
18. Wireless Board:
 - a. Maximum Resolution: 1920 x 1080p
 - b. Wireless Communication: 2.4GHz, IEEE802.11 b/g/n
5GHz, IEEE802.11 a/n
 - c. Input / Output Terminals: LAN, USB 2.0, Wireless Adapter USB 2.0
 - d. Power Supply: From the Monitor

2.31 FLAT PANEL DISPLAY, 43"

- A. Basis of Design: Sharp PN-Y436.
- B. Approved Equals: NEC, Samsung.
- C. Specifications:

1. Screen Size: 43"
2. Display Type: TFT LCD
3. Native Display Resolution: 1920 x 1080p
4. Max Brightness: 450 cd/m²
5. Contrast Ratio: 1100:1
6. Viewing Angle: 178°
7. Active Screen Area: 37-1/16" x 20-27/32"
8. Response Time: 12 ms
9. Backlight: LED, edge lit
10. Power Supply: 100V – 240V AC
11. Power Consumption: 76 W
12. Speaker Output: 7W + 7W
13. Input Terminals: DVI-D, Mini-D, HDMI, RGB, Audio, RS-232C
14. Output Terminals: DVI-D, Audio, RS-232C
15. Input / Output Terminals: LAN
16. Dimensions: 38"W x 1-13/16"D x 22"H
17. Weight: 23.1 lbs

2.32 FLAT PANEL DISPLAY, 60" TOUCH SCREEN

- A. Basis of Design: Sharp PN-L603W.
- B. Approved Equals: NEC, Samsung.
- C. Specifications:
 - 1. Screen Size: 60"
 - 2. Display Type: LCD
 - 3. Native Display Resolution: 1920 x 1080p
 - 4. Max Brightness: 450 cd/m²
 - 5. Contrast Ratio: 4,000:1
 - 6. Viewing Angle: 176°
 - 7. Active Screen Area: 52-5/16" x 29-7/16"
 - 8. Response Time: 6 ms
 - 9. Touch Technology: IR (Infrared blocking detection method)
 - 10. Multi Touch: 10 points
 - 11. Protection Glass: Thickness (3.0mm), Shock Resistance (130 cm)
 - 12. Touch Pen: Wireless communication method
 - 13. Wireless Controller: Wireless communication method
 - 14. Backlight: LED, edge lit
 - 15. Power Supply: 100V – 240V AC
 - 16. Power Consumption: 170 W
 - 17. Speaker Output: 10W + 10W
 - 18. Input Terminals: Mini-D, HDMI, RGB, Audio, RS-232C, DisplayPort
 - 19. Output Terminals: Audio, DisplayPort
 - 20. Dimensions: 56-9/16"W x 3-11/16"D x 35-1/16"H
 - 21. Weight: 105.9 lbs.

2.33 FLAT PANEL DISPLAY, 60"

- A. Basis of Design: Sharp PN-E602.
- B. Approved Equals: NEC, Samsung.
- C. Specifications:
 - 1. Screen Size: 60"
 - 2. Display Type: LED
 - 3. Native Display Resolution: 1920 x 1080p
 - 4. Max Brightness: 450 cd/m²
 - 5. Contrast Ratio: 4,000:1
 - 6. Viewing Angle: 176°
 - 7. Active Screen Area: 52-5/16" x 29-7/16"
 - 8. Response Time: 6 ms
 - 9. Backlight: White LED, edge lit
 - 10. Power Supply: 100V – 240V AC
 - 11. Power Consumption: 170 W

12. Speaker Output:	7W + 7W
13. Input Terminals:	HDMI, RGB, Audio, Rs-232C
14. Output Terminals:	Audio, RS-232C
15. Dimensions:	55-13/32"W x 3-3/8"D x 32-5/32"H
16. Weight:	83.8 lbs

2.34 FLAT PANEL DISPLAY, 70"

A. Basis of Design: Sharp PN-E702.

B. Approved Equals: NEC, Samsung.

C. Specifications:

1. Screen Size:	70"	
2. Display Type:	LED	
3. Native Display Resolution:	1920 x 1080p	
4. Max Brightness:	450 cd/m^2	
5. Contrast Ratio:		4,000:1
6. Viewing Angle:		176°
7. Active Screen Area:	69-3/4" x 39-1/4"	
8. Response Time:		6 ms
9. Backlight:	White LED, edge lit	
10. Power Supply:	100V – 240V AC	
11. Power Consumption:	270 W	
12. Speaker Output:	7W + 7W	
13. Input Terminals:	HDMI, RGB, Audio, Rs-232C	
14. Output Terminals:	Audio, RS-232C	
15. Dimensions:	63-19/32"W x 3-15/16"D x 37-9/32"H	
16. Weight:	110 lbs.	

2.35 FLAT PANEL DISPLAY MOUNT, 42" / 43"

A. Basis of Design: Chief Manufacturing TS525TU Thinstall dual swing arm wall mount

B. Approved Equals: Premier, Peerless.

C. Specifications:

1. Lateral Shift:	16"
2. Minimum Depth:	1.5"
3. Mounting Pattern Compatibility:	100 x 100 mm – 800 x 400 mm
4. Orientation:	Landscape
5. Typical Screen Sizes:	37" – 58"
6. Tilt:	0 – 15°
7. Maximum Extension:	25"
8. Maximum Screen Thickness:	5"
9. Pivot:	+/- 90°

2.36 FLAT PANEL DISPLAY MOUNT, 60"

- A. Basis of Design: Chief Manufacturing TS525TU Thinstall dual swing arm wall mount
- B. Approved Equals: Premier, Peerless.
- C. Specifications:
 - 1. Lateral Shift: 16"
 - 2. Minimum Depth: 1.5"
 - 3. Mounting Pattern Compatibility: 100 x 100 mm – 800 x 400 mm
 - 4. Orientation: Landscape
 - 5. Typical Screen Sizes: 37" – 58"
 - 6. Tilt: 0 – 15°
 - 7. Maximum Extension: 25"
 - 8. Maximum Screen Thickness: 5"
 - 9. Pivot: +/- 90°

2.37 FLAT PANEL DISPLAY MOUNT, 60" / 70"

- A. Basis of Design: Chief Manufacturing LSM1U Large Fusion Micro-Adjustable Fixed Mount.
- B. Approved Equals: Premier, Peerless.
- C. Specifications:
 - 1. Lateral Shift: 17.4"
 - 2. Minimum Depth: 2"
 - 3. Mounting Pattern Compatibility: 100 x 100 mm – 880 x 400 mm
 - 4. Orientation: Landscape
 - 5. Typical Screen Sizes: 37" – 63"

2.38 WALL MOUNTED LOUDSPEAKER

- A. Basis of Design: Innovox Flex Video Series, Part number FP-H2.
- B. Approved Equals: Brown Innovations, Leon Sound.
- C. Specifications:
 - 1. Speaker Type: Ultra Slim Two-Channel Horizontal Loudspeaker
 - 2. Dimensions: 4.10"H x 32 – 96" (Custom W) x 2.10"D
 - 3. Frequency Range: 120 Hz to 20 kHz
 - 4. Power Capacity: 180 W
 - 5. Nominal Sensitivity: 92 dB, 1W/1M
 - 6. Nominal Impedance: 6 ohms
 - 7. Weight: 15 - 22 lbs.

2.39 AV RACK 1/2/3/5

- A. Basis of Design: Middle Atlantic CFR Series Rack, CFR-10-16.
- B. Approved Equals: Brand Specific.
- C. Specifications:
 - 1. EIA compliant 19" cabinet rack
 - 2. Overall dimensions shall be 19.25"W x 18.44"H with useable depth of 16"
 - 3. Rack capacity of 250 lbs.
 - 4. Space: 10 rackspaces
 - 5. Constructed of the following materials:
 - a. Top and Bottom shall be 16-gauge steel
 - b. Rackrail shall be constructed if 11-gauge steel with tapped 10-32 mounting holes in universal EIA spacing
 - 6. Finished in a durable black powdercoat
 - 7. Include two adjustable side mounted horizontal lacing bars for enhanced cable management
 - 8. Cabinet frame shall be:
 - a. UL listed
 - b. GREENGUARD Indoor Air Quality Certified
 - c. RoHS EU Directive 2002/95/EC compliant
 - d. Warrantied to be free from defects in material or workmanship under normal use and conditions for the lifetime of the product.

2.40 AV RACK 4

- A. Basis of Design: Middle Atlantic ERK Series Rack, ERK-3520LRD.
- B. Approved Equals: Brand Specific.
- C. Specifications:
 - 1. EIA compliant 19" cabinet rack
 - 2. Overall dimensions shall be 22"W x 65-3/8"H with useable depth of 20"
 - 3. Rack capacity of 2500 lbs.
 - 4. Space: 35 rack spaces
 - 5. Constructed of the following materials:
 - a. Top and Bottom shall be 16-gauge steel
 - b. Rackrail shall be constructed if 11-gauge steel with tapped 10-32 mounting holes in universal EIA spacing
 - 6. Finished in a durable black powdercoat
 - 7. Include two adjustable side mounted horizontal lacing bars for enhanced cable management
 - 8. Cabinet frame shall be:
 - a. UL listed
 - b. GREENGUARD Indoor Air Quality Certified
 - c. RoHS EU Directive 2002/95/EC compliant

- d. Warranted to be free from defects in material or workmanship under normal use and conditions for the lifetime of the product.

2.41 PROJECT CABLING

- A. Specifications: The following cables are basis of design. Contractor shall use the listed or provide an owner approved equal for use in this project:

1.	HDMI Pro Series	HDMI	Extron, 26-650-xx
2.	XTP DTP	24 AWG TSP	Extron, 22-235-03
3.	Control/RS-232	4-Pair 24 AWG	Belden, 82504
4.	Composite Video	Three 25 AWG Coax	Belden, 1277P
5.	CAT-6	4-Pair 24 AWG	Belden, 4813
6.	General Speaker	14 AWG TSP	Belden, 1861A
7.	25/70V Speaker	18 AWG TSP	Belden, 6300UE
8.	Audio-DR	24 AWG TSP	Belden, 1801B
9.	Audio	3.5mm to Stereo	Belden, 1800A
10.	MIC, Line	22 AWG TSP	Belden, 9451P

PART 3 - EXECUTION

3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

3.2 CUTTING AND PATCHING

- A. General: Perform cutting and patching in accordance with the following requirements:
 - 1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Remove and replace defective Work.
 - b. Remove and replace Work not conforming to requirements of the Contract Documents.
 - c. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.
 - 2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
 - 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 - 4. Protection of Installed Work: During cutting and patching operations, protect adjacent installations. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 - 5. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications

refer to the materials and methods required for the surface and building components being patched.

3.3 INSPECTION

- A. Before installing electronic equipment, carefully inspect the installed Work of all other Trades. Verify that all such Work is complete to the point where the installation of electronic equipment may properly commence. Verify that all Audiovisual Equipment spaces are free of airborne contaminants prior to the installation of electronic equipment.
- B. Verify that all equipment is installed in accordance with all pertinent codes and regulations, the original design, and the referenced standards.
- C. In the event of discrepancy, immediately notify the Engineer.
- D. Do not proceed with installation in areas of discrepancy until such discrepancies have been fully resolved.
- E. Return to original (preconstruction) condition any work disturbed during system installation.

3.4 INSTALLATION

- A. Install all equipment in strict accordance with the manufacturer's recommendations, reviewed shop drawings and EIA/TIA standards.
- B. Secure equipment with fasteners suitable for the use, materials, and loads encountered. If requested, submit evidence proving suitability. Do not attach electrical materials to roof decking, removable or knockout panels, or temporary walls and partitions, unless indicated otherwise.
- C. National Electrical Code requirements are applicable to all work.
- D. Where the Engineer determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled as directed at no additional cost to the Owner. "Conveniently accessible" is defined as being capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, pumps, belt guards, transformers, piping, and duct work.
- E. AV equipment racks are to be fully assembled and tested in the contractor's shop. All wiring and terminations integral to the rack shall be completed prior to delivering to the job site.
- F. All programming of digital signal processors and integrated control equipment is to be performed in the contractor's shop prior to delivery to the job site. All equipment is to be fully tested.
- G. Wiring shall be color coded, uniform, and in accordance with the NEC and manufacturer's instructions.

- H. Equipment shall be firmly secured, plumb, and level.
- I. All cables runs to the main equipment racks shall be tagged and identified.
- J. Coordinate all work with other trades and Contractors.
- K. Grounding of cables and peripheral equipment shall be installed per manufacturer's direction to eliminate noise induction and achieve optimum system performance.
- L. All unused tap-off and splitter outputs are to be terminated according to manufacturer's guidelines.
- M. Properly align and balance all video projection systems and monitors.
- N. Install front-projection screens at locations indicated to comply with screen manufacturer's written instructions.
- O. Install front-projection screens with screen cases in position and in relation to adjoining construction indicated. Securely anchor to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.
 - 1. Install low-voltage controls according to NFPA 70 and complying with manufacturer's written instructions.
 - a. Wiring Method: Install wiring in raceway except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
 - 2. Test electrically operated units to verify that screen controls, limit switches, closures, and other operating components are in optimum functioning condition.

3.5 WORK PERFORMANCE

- A. Coordinate location of equipment with other trades to minimize interferences.
- B. Holes through concrete and masonry in new and existing structures shall be cut with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills shall not be allowed, except where permitted by the Engineer as required by limited working space
- C. Holes shall not affect structural sections such as ribs or beams.
- D. Holes shall be laid out in advance. The Engineer shall be advised prior to drilling through structural sections for determination of proper layout.
- E. Hangers and other supports shall support only equipment and materials. Provide not less than a safety factor of 5, which shall conform to any specific requirements in the Construction Documents.

3.6 PROTECTION AND CLEANING OF SYSTEMS AND EQUIPMENT

- A. Protect all materials and equipment from damage during storage at the Site and throughout the construction period. Equipment and materials shall be protected during shipment and storage against physical damage, dirt, moisture, cold and rain.
- B. Prevent damage from rain, dirt, sun and ground water by storing equipment on elevated supports and covering all sides with securely fastened protective rigid or flexible waterproof coverings.
- C. Protect piping by storing it on elevated supports and capping the ends with suitable closure material to prevent dirt accumulation in the piping.
- D. During construction, cap the top of all conduits and raceway installed vertically.
- E. During installation, protect equipment against entry of foreign matter on the inside, and vacuum clean both inside and outside before testing and operating.
- F. Damaged equipment, as determined by the Engineer, shall be replaced.
- G. Protect painted surfaces with removable heavy kraft paper, sheet vinyl or equal, installed at the factory and removed prior to final inspection.
- H. Repaint damaged "FINISH" paint on equipment and materials with painting equipment and finished with same quality of paint and workmanship as used by the original manufacturer so repaired areas are not obvious

3.7 IDENTIFICATION

- A. Uppercase letters of uniform height; centered on device, cover plate, or enclosure; engraved letters filled with a contrasting color; and all characters made clearly and distinctly.
- B. Use abbreviations defined in the contract documents whenever possible. Use plan designations for labeling unless indicated otherwise.

3.8 LABELING

- A. All cables shall be properly identified using a high quality thermal transfer labeling device such as the Panduit RhinoPro 3000 or equal.
- B. Cable
 - 1. Provide typewritten labels on both ends of all audio-visual system cabling. Locate label within 6" of cable termination. Cover label with clear heat shrink tubing.
 - 2. Label designation to consist of letter indicating type of cable (i.e. S for Speaker, L for Line Level, C Control, M Microphone etc.) and a number. Numerical designations shall be sequential.
- C. Power Outlets

1. Power outlet labels are to be mechanically generated.
2. All power outlets designated for audiovisual equipment shall be labeled "AUDIO VISUAL EQUIPMENT ONLY". On top.
3. Provide a second label on the bottom of the outlet cover plate indicating service panel number and circuit breaker number.
4. Text lettering to be 1/8" high.

D. Rack Mounted Electronic Components

1. Electronic component labels are to be mechanically generated.
2. All inputs are to be labeled identifying source location of signal.
3. All outputs are to be labeled identifying signal destination.
4. Provide 1/4" diameter indicator dot showing level setting for all rotary knobs, sliders, and pushbutton switches.
5. Power switches shall be clearly labeled indicating switch is to be left in the on position at all times.

E. Portable Electronic Components

1. Electronic component labels are to be mechanically generated.
2. All inputs are to be labeled identifying source location of signal.
3. All outputs are to be labeled identifying signal destination.
4. Provide 1/4" diameter indicator dot showing level setting for all rotary knobs, sliders, and pushbutton switches.
5. Power switches shall be clearly labeled.
6. Provide drawing illustrating hookup of portable equipment. Show required interconnection with input panel. Drawing should clearly indicate type of patch cable required for termination.

F. Labeling Throughout DSP Software

1. Sufficient labeling shall be provided within the software of all digital signal processors.
2. Labels shall be provided for each component of the signal chain. Label shall define type of component and system being fed. Ex. "8 input mixer for Gymnasium".
3. Inputs and outputs of all devices shall be clearly labeled defining the source feeding into a device, and the location where an output is being fed to. Ex. The first input of a mixer is fed by the microphone input for a paging system. Input should be labeled "Page Mic Input".

3.9 CABLE TERMINATIONS AND DRESS

A. Installation of Audiovisual conductors shall adhere to the following:

1. Cables shall be installed in Panduit wire duct (or approved equal) in all cabinets and racks for wire and cable management.
2. Cables shall be secured to equipment cabinet backboards, console members or to other system components using Panduit wire duct (or approved equal). Contractor shall furnish and install cable support posts, cable clamps or wraps, if required, to facilitate system installation where plastic wire duct use is not possible.

3. All cables and/or conductors shall be terminated with approved cable termination connectors compatible with the specific termination.
4. Label all cables on both ends and on all termination points.

3.10 CLEANING

- A. Daily during construction and prior to Owner acceptance of the building, remove from the premises and dispose of all packing material and debris caused by work performed under specifications.
- B. Remove all dust and debris from interiors and exteriors of electrical equipment. Clean accessible current carrying elements prior to being energized.

3.11 TESTING EQUIPMENT

- A. The following minimum list of equipment is required:
 1. 1/3rd octave real-time analyzer. Ivi IE-45, Goldline DSP30, or equivalent.
 2. Software based dual FFT real-time transfer function analyzer allowing for frequency domain comparison of two signals yielding precise frequency (magnitude and phase) response for the device or system under test in real time. SIA SmartLive, EASERA, or equivalent.
 3. High impedance multi-meter. Typical of Fluke or Simpson.
 4. Clamp on ammeter, peak and average measurement capability. Typical of Fluke or Simpson.
 5. 400 MHz dual trace oscilloscope. Typical of Tektronix.
 6. Loudspeaker impedance meter. Capable of swept impedance versus frequency plots. Typical of TEF-25 or LinearX LMS.
 7. Omni-directional test microphone. Typical of Audix TR40A, Earthworks M-30BX, or equivalent.
 8. Laptop computer. Windows Vista. Intel Core 2 processor, 2.0 GHz, 2 GB ram, 1280 x 800, stereo line level input capable of 24 bit sampling resolution and 48k sampling rate.
 9. Test Microphone Preamplifier. Two channels. 24-bit A/D converters, 106 dB dynamic range (24-bit recording mode). 48-volt phantom power. High impedance low-noise instrument DI. Line or tape level inputs. Zero-latency analog monitoring. Bus powered from host computer. Sound Devices USBpre or Sound Technologies Model 90.
 10. Cable Tester. Tests NL4, 5 pin DIN, BNC, XLR, TRS, RCA, and 3.5 mm type connectors. Tests for continuity and wiring configuration.
 11. Polarity Tester. Galaxy Cricket, Gold Line, or equivalent.
 12. Video Test Generator. Capable of generating component, S-video, composite, SDI, and HDSDI test signals. Typical of Extron VTG 400.

3.12 SYSTEM INITIALIZING AND PROGRAMMING

- A. The System shall be turned on and adjustment made to meet requirements of the specifications and on-site conditions.

- B. The System shall be programmed to function as specified.
- C. Any special programming shall be documented and a written copy given to the Owner.

3.13 SYSTEM TEST PROCEDURES

- A. Testing to be performed in the Contractors shop prior to delivery.
 - 1. Test 120VAC power equipment and hardware internal to all equipment racks. Test all conductors for shorts, opens, and polarity.
 - 2. When sequencing applies to multiple power controllers, verify all controllers sequence in the desired order when activated by the master power control switch. All source level control and signal processing sequences first, amplifiers last. Reverse order for power down.
 - 3. Fully charge all UPS systems. Test unit by removing power thereby causing the unit to switch to battery reserve.
- B. Testing to be performed at the job site prior to powering the system.
 - 1. Verify all signal and control cables are free of shorts and opens prior to termination of head-end electronics.
 - 2. Test all 120VAC power sources for correct polarity and voltage. Test grounding system for continuity. Notify Electrical Contractor of any problems.
- C. The System shall be completely tested to assure that all components are hooked up and in working order. Inspect system for defects. Correct all causes of such defects. If the cause is outside of the scope of the Division 274100 series scope of work, promptly notify the Architect in writing, indicating the cause of the defect and suggested corrective procedures.
- D. The system shall be capable of operating free of interference, hum bars, and distortion under normal operating conditions.
- E. The System shall be pre-tested by the Contractor and certified, in writing, to function in accordance with the plans and specification.
- F. Test all cabling for continuity. Verify all lines are free from shorts and opens. Testing shall include all passive components including tap-offs and splitters.
- G. Test all cabling verifying that all cables are terminated accordingly.
- H. All outlet signal level readings shall be within +/-2 dB of manufacturers recommended signal level for that component.
- I. Verify display systems are operating free of banding, bending, blooming, chroma delay, convergence, ghosting, humbars/ground loops, jitter, luma display, smearing, and all other symptoms of defective equipment, incorrect termination, and incomplete system setup.
- J. Provide written documentation showing all test results.

- K. The System shall be final tested in the presence of the Engineer.

3.14 SUBSTANTIAL COMPLETION

A. General

- 1. Upon completion of the work, remove excess debris, materials, equipment, apparatus, tools and the like and leave the premises clean, neat and orderly.

B. Results Expected

- 1. All equipment and materials shall be in place and all systems shall be demonstrated to be operationally complete.
- 2. All testing, start-up and cleaning work shall be complete.
- 3. All documented testing results are submitted and approved by the Engineer. ANY COMPONENT OF THE SYSTEM THAT FAILS TO MEET TEST PERFORMANCE STANDARDS SHALL BE REPLACED BY THE CONTRACTOR AT NO ADDITIONAL COST.
- 4. The Contractor shall provide test equipment to the Engineer to spot check test result documentation.
- 5. All O & M Manuals and Record Documents are reviewed and accepted.
- 6. Substantial Completion inspection is performed and granted. The Substantial Completion inspection punch list is completed by the Contractor.
- 7. Transmittal letter listing delivery of complete spare parts inventory.

PART 4 - PROJECT CLOSEOUT

4.1 FINAL SYSTEM TESTING/DEMONSTRATION

- A. Upon completion of approved testing procedure and submittal of testing documentation as described above, the Audiovisual Integrator shall notify the Engineer, who will visit the project for a demonstration of the systems and an inspection of the completed work in conformance with the Construction Documents. It is mandatory for a representative from the Contractor directly responsible for the project to be present during demonstration and inspection periods. Demonstration and inspection of all systems by the Engineer shall take place prior to turning over the system to the owner/user. The Contractor shall allow two (2) consecutive days for performance testing.
- B. Items which do not comply with the Contract Documents, or which function incorrectly, will be listed and the list will be submitted by the Engineer to the Contractor.
- C. After all corrections have been made, the Contractor shall notify the Engineer who will re-check the system for compliance of all items listed. IF THE ENGINEER IS REQUIRED TO RETURN TO THE SITE FOR FURTHER INSPECTIONS, ALL LABOR AND TREL EXPENSES SHALL BE REIMBURSED BY THE CONTRACTOR.
- D. The Contractor shall provide high quality source materials for all video and audio media types as used in the system designs for the demonstration of all playback devices.

- E. The Contractor shall provide computer and video signal generator that is capable of producing all signal types used in the system designs for demonstration of all computer/video displays.
- F. The Contractor shall load all input sources with source material and switch randomly between sources to demonstrate that all displays are optimized for each source and that all control systems are functioning properly.

4.2 TRAINING

- A. Provide training after all final tests and adjustments have been completed. Instruct the Owner's personnel according to the approved Training Plan specified above in "Training Plan and Documentation." Training shall cover all aspects of systems operation, maintenance and programming, and will be provided by the responsible Contractor technical representatives.
- B. Provide written operating instructions specific to the basic operation of the system. Basic instructions should cover all operational aspects of the system required for basic operation including system powering, signal patching and routing, and level control. These instructions are to be laminated and located with the main system power control.
- C. Schedule training sessions to meet the needs of facility personnel as determined by the Owner. Provide training during second and third shifts if the Owner determines it is necessary.
- D. Record all training sessions. Submit an edited DVD copy (maximum of 2 hours) to the Engineer for review and approval. Present all materials used in the training session on the video. Any DVD found to be inferior in recording or material content shall be reproduced at no cost until an acceptable tape is submitted.
- E. Provide a minimum of 16 hours of training. All training is to be completed during the time frame established during scheduling with the owner and training may not necessarily be in continuous periods.

4.3 MAINTENANCE MATERIALS

- A. All special tools for proper operation and maintenance of the equipment provided under this Specification shall be delivered.
- B. Provide spare materials as indicated in Contract Documents and as required for proper maintenance of systems.

4.4 WARRANTY, WARRANTY SERVICE AND MAINTENANCE

- A. Warranty
 - 1. The Audiovisual system shall be fully guaranteed for a period of two (2) years beginning on the date of Owner acceptance.

2. The guarantee shall include the entire scope of work including all equipment, devices, materials, cable/wire, software and installation.
3. Work shall be guaranteed to be free from defects. Any defective materials or workmanship, as well as damage to the Work of all other Trades resulting from same, shall be replaced or repaired as directed by the Owner for a period of two (2) years from the date of Owner final acceptance. The Contractor shall provide written warranties for all systems and all buildings to the Owner.
4. The guarantee shall exclude acts of God, vandalism, physical abuse or operator misuse.
5. Acceptance by a manufacturer of an order for equipment for this contract signifies acceptance of this warranty. During the warranty period there shall be no charge to the owner for equipment, material, software, etc. for guarantee work.
6. During the warranty period, there shall be no charges to the Owner for service calls (mileage, labor, travel, expenses, etc.) for guarantee work.

B. Warranty Service

1. Warranty service shall be provided as part of this Contract by the Contractor during the warranty period.
2. Warranty service agreement must be submitted separately and must contain the name, voice phone number, facsimile phone number and pager number of the service provider capable of meeting the response time as defined by the Engineer.
3. This service shall consist of the following:
 - a. 24-hour phone number.
 - b. Technician's factory trained by the manufacturers of the system's components.
 - c. Authorized representation of the manufacturer via an agreement of factory support.
 - d. Five years' experience (minimum) servicing systems of the type included in this project.
 - e. Capability of making additions or changes to the software systems used in this project.
 - f. Capability of servicing the individual system components and the total audiovisual system.
 - g. Equipment and knowledge to test all specified equipment and devices.
 - h. Current system documentation including but not limited to the following:
 - 1) Wiring diagrams.
 - 2) Operation and maintenance manuals.
 - 3) Software programs.
 - 4) Other documentation as required to provide assistance to the owner in the operation and maintenance of the systems.
 - 5) All documents shall be made available to Owner upon request.
 - 6) Upon termination of maintenance agreement all system documents shall be furnished to owner for maintenance continuity.
4. The Owner and/or Engineer shall notify the Contractor in writing, outlining operational malfunctions or defects in the Division 27 4100 series audiovisual system. This report shall be faxed to the service provider which will establish the date and time of problem notification.

5. Upon successful completion of warranty service, the responsible technician shall return a copy of the original service request to the facility with a detailed description of the problem found, and corrective action taken including a list of equipment/parts/software repaired or replaced. The technician shall also sign the on- site service log at the facility.
6. The Contractor shall maintain a repair parts inventory sufficient to maintain the response times specified. All parts used from the Owner's spare parts inventory for warranty service shall be replaced at no cost to the Owner.
7. Response Times:
 - a. Telephone Call Response:
 - 1) Within 1 hour of request
 - b. On-Site Response:
 - 1) M-F 8:00 a.m. to 5:00p.m. - Within 4 hours of request
 - 2) Saturday, Sunday or after 5:00p.m. - Response the next calendar day.

END OF SECTION 267413

SECTION 267500**TELECOMMUNICATION INFRASTRUCTURE CABLING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes wire, cable, connecting devices, installation, and testing for wiring systems to be used as signal pathways high-speed data transmission. This includes cabling designated as "Data" and "Voice (over IP)".
- B. Structured Cabling System Warranty: The Data Infrastructure Cabling system shall be warranted as a structured cabling system by the connecting hardware manufacturer. The Contractor shall be a Certified Installer by the manufacturer. The Contractor shall furnish all labor, supervision, tooling, and miscellaneous mounting hardware and consumables necessary to qualify for the manufacturer's system warranty. The Contractor shall initially have and maintain current status a certified installer with the warranting manufacturer, including all training requirements, for the duration of the Project. Refer to Warranty paragraph below for further details.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. LAN: Local area network.
- D. PVC: Polyvinyl chloride
- E. UTP: Unshielded twisted pair.

1.4 REFERENCES

- A. EIA/TIA-568-A: Commercial Building Telecommunications Cabling Standard.
- B. EIA/TIA-569: Commercial Building Standard for Telecommunications Pathways and Spaces.

- C. EIA/TIA-606: Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.
- D. EIA/TIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.
- E. NEC: National Electric Code.
- F. BISC *TDM*: Building Industries Consulting Services, *International Telecommunications Distribution Design Manual*.

1.5 SUBMITTALS

- A. Product Data: Include data on features, ratings, and performance for ALL components specified.
- B. Shop Drawings: Include dimensioned plan and elevation views of each individual component. Show equipment assemblies, method of field assembly, workspace requirements, and access for cable connections.
 - 1. Provide bound full size sets of scaled architectural floor plans with Installer's border sheet depicting outlet and equipment locations and proposed route of backbone cabling. Label all outlets utilizing proposed labeling scheme. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with most recent release of AutoCAD upon request. Copies of Project Construction Documents or details there from may NOT be part of Shop Drawings.
 - 2. Provide key to labeling scheme with description and multiple examples.
 - 3. All rack elevations depicting manufacturer and model numbers for patch panels, fiber trays, wire management and rack.
 - 4. Outlet faceplate elevations depicting manufacturer and model numbers for faceplate and jacks.
- C. Qualification Data, for Manufacturers: Provide copy of proposed structured cabling system warranty with appropriate documentation that warranty has been applied for.
- D. Qualification Data for Installer: Provide letter documenting personnel, projects, and indicating compliance with Installer Qualifications as required in paragraph 1.6 QUALITY ASSURANCE.
- E. Cabling Test Reports. Provide hard copy and digital files on a compact disk. Include viewing software on disk.
- F. Cabling Schedule: Provide hard copy and digital spreadsheet files on a compact disk. Spreadsheet files must be Microsoft Excel compatible format.
- G. As-built Drawings: Prior to final acceptance, provide three complete bound full size sets of scaled architectural floor plans with Installer's border sheet depicting final outlet and equipment locations and route of backbone cabling. All outlets shall be labeled on As-builts as labeled at project site. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with most recent release of AutoCAD upon

request. Copies of Project Construction Documents or details there from may NOT be part of as-builts. As-builts for Intercom System, Data Infrastructure System, and MATV System shall be bound together. Furnish electronic record of all plan drawings on compact disk, in AutoCAD software format.

- H. Operation and Maintenance Data: For voice and data communication cabling to include in emergency, operation, and maintenance manuals.
- I. At Project Completion
 - 1. As-Builts: Prior to final acceptance, provide three complete bound full size sets of scaled architectural floor plans with Installer's border sheet depicting final device and equipment locations and route of backbone cabling. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with most recent release of AutoCAD upon request. Copies of Project Construction Documents or details there from may NOT be part of as-builts. Provide electronic copy of As-builts in submittal.
 - 2. Operation And Maintenance Manuals: Prior to final acceptance, provide three complete sets of operation and maintenance manuals for the system. The operation manual shall contain all instruction necessary for the proper operation of the installed system and manufacturer's instruction. The maintenance manual shall contain all "proof of performance" information as required in Section 3, and all manufacturer's maintenance information, and copies of non-priority computer programs and system set up disks documenting all programmable features for the installed system.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. System Installer shall be a manufacturer certified installer under the Warranty program listed below at time of bid and shall possess a NC Specialty Low-voltage License.
 - 2. System Installer must have installed within the last three years a minimum of three projects of similar scope and complexity.
 - 3. System Installer shall employ a job superintendent or project manager during the course of the installation to provide coordination of work. This person shall maintain current RCDD® (Registered Communications Distribution Designer) registration and shall be responsible for quality control during installation, equipment set-up, and testing.
 - 4. System Installer's installation personnel shall meet manufacturer's training and education requirements to comply with Warranty program.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Surface-Burning Characteristics of Cabling: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

- a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 or less
- D. Comply with NFPA 70.
- E. 25-Year Performance Warranty

The warranty proposed for this infrastructure must meet the following minimum requirements and be a total sole source warranty supplied by the General contractor specifying a single point of contact for warranty claims on the copper or fiber installation. The warranty is to be comprised of the following segmented parts:

- 1. 25-Year System Performance Warranty (Not Component Only). Includes copper and fiber optic cabling.
- 2. Warrant all current and all future network applications designed for a TIA/EIA 568-B compliant infrastructure.
- 3. Cover labor and materials for repair or replacement of defective products.
- 4. Warranty to be issued directly to the end-user (not to the Contractor)

1.7 COORDINATION

- A. Coordinate layout and installation of voice and data communication cabling with Owner's telecommunications and LAN equipment suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute to other participants.
 - 3. Adjust arrangements and locations of distribution frames and cross-connect and patch panels in equipment rooms and wiring closets to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
- B. Pre-Installation Meeting: Electrical Contractor and System Installer shall attend a pre-installation meeting with Engineer and Owner to discuss issues that pertain to telecom work.
- C. Coordinate layout and installation of all equipment and all pathways with other construction, including conduit, piping, and adjacent surfaces. Maintain proper work space clearances.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cable: 250 feet of each size and type used for Project. Furnish on reels.

2. Patch-Panel Units: One of each type for every six (6) installed, but no less than one.
3. Connecting Blocks: One of each type for every 25 installed, but no less than one.
4. Outlet Assemblies: One of each type for every 25 installed, but no less than one.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Structured Cabling System Manufacturers: Subject to compliance with requirements, manufacturers offering structured cabling systems that may be incorporated into the Work include the following:
 1. Hubbell Premise Wiring, Hubbell Incorporated
 2. Leviton Manufacturing Co., Inc.
 3. SYSTIMAX by CommScope Inc.
 4. Ortronics, Inc./Legrand
 5. Panduit Corp.
 6. General Cable
- B. It is the intent of the manufacturers listed for Structured Cabling System to denote the quality standard of product desired and not to restrict bidders to a specific brand, make, manufacturer or specific name. The manufacturers and products listed below are used only to set forth and convey to bidders the general style, type, character, and quality of product desired. Substitution of equivalent products will be acceptable according to the following paragraph.
 1. Substitution of Equivalent Products: Substitution of manufacturers and products equivalent to those below shall be submitted to the Engineer for approval; such approval shall be made by the Engineer prior to the opening of bids and included in addenda. All substitution requests shall be received by the Engineer a minimum of 10 days prior to the opening of bids.
- C. Other Products: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include are listed below, but not limited to the following:
 1. Manufacturers for Distribution Racks:
 - a. Hubbell Premise Wiring.
 - b. Chatsworth/Dracon.
 - c. Cooper B-Line.
 - d. Rack Technologies.
 - e. Newton Instrument Company.
 - f. Lowell, Inc.

2.2 SYSTEM REQUIREMENTS

- A. General: Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.
- B. Single Source: All copper and fiber termination equipment shall be from a single manufacturer. All copper cabling shall be from a single manufacturer and fiber cabling shall be from a single manufacturer.

2.3 MOUNTING ELEMENTS

- A. Backboards: 3/4-inch, interior-grade, fire-retardant-treated plywood.
- B. Equipment Racks: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 1. Approximate Module Dimensions: 84 inches high by 22 inches wide.
 - 2. Mounting: Rack shall be drilled for #12-24 x 5/8" equipment mounting screws.
 - 3. Finish: Baked-polyester powder coat.
 - 4. Support: Attach base to concrete floor using expansion bolts per manufacturer's instructions and attach top of rack to crossing cable tray.
 - 5. Refer to floor plans for additional requirements.

2.4 TWISTED-PAIR CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

- A. Cables: Listed as complying with Category 6 of TIA/EIA-568-A.
- B. Conductors: Solid copper.
- C. UTP Cable: Comply with TIA/EIA-568-A. Four, thermoplastic-insulated, individually twisted pairs of conductors; No. 24 AWG, color-coded; enclosed in overall jacket. Jacket Color as follows:
 - 1. Horizontal Voice (Over IP): Blue
 - 2. Horizontal Data: Blue
 - 3. Horizontal Security Camera: Green
- D. All cable shall be plenum rated (CMP).
- E. UTP Cable Connecting Hardware: Comply with TIA/EIA-568-A, using modules designed for punch-down caps or tools.
 - 1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
 - 2. IDC Connecting Hardware: Consistent throughout Project.

- F. Patch Panel: Modular panels housing multiple jack units with Category 6 compliant IDC-type connectors at each jack for permanent termination of pair groups of installed horizontal cables. Jacks shall be configured in replaceable modular groups of six jacks each.
 - 1. Number of Jacks supported per Field/Panel: **48 Port (2U)**. With number of panels per IDF as required to terminate all horizontal data cables and provide 15% spare.
 - 2. Provide separate dedicated patch panels for horizontal data, voice (over IP), and security.
 - 3. Mounting: Rack.
- G. Workstation Faceplates: Modular style faceplate supporting number of ports/jacks as shown on plans. Faceplate shall incorporate covered labeling slots at the top and bottom of faceplate.
 - 1. Faceplate: High-impact plastic; color: Shall be approved by architect.
 - 2. Mounting: Flush, unless otherwise indicated.
 - 3. Refer to plans for additional details and types.
- H. Surface Outlets: Small form factor housing modular jack assemblies designed for surface mounting and supporting number of ports shown on plans.
- I. Data Jacks and Jack Assemblies for UTP Cable: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals. Listed as complying with Category 6 of TIA/EIA-568-B.2.
 - 1. Horizontal Voice (Over IP): Blue
 - 2. Horizontal Data: Blue
 - 3. Horizontal Security Camera: Green

2.5 VOICE RISER CABLES AND TERMINATIONS

- A. Cables: Listed as complying with Category 3 of TIA/EIA-568-A.
- B. Conductors: Solid copper.
- C. UTP Cable: Listed as complying with Category 3 of TIA/EIA-568-A. Multiple groups of twenty-five, thermoplastic-insulated, individually twisted pairs of solid copper conductors; #24 AWG, fully color-coded beginning with white-blue pair of standard 25 pair binder group; enclosed in white CMP rated PVC jacket.
- D. OSP/Flooded Cable: Flooded and shielded PIC cable designed for duct applications. Multiple groups of twenty-five, polyolefin-insulated, individually twisted pairs of solid copper conductors; #24 AWG, fully color-coded beginning with white-blue pair of standard 25 pair binder group.
 - 1. Flooding Compound: Core assembly shall be filled with an 80-degree Celsius ETPR compound, completely filling the interstices between pairs.
 - 2. Shielding: Corrugated, 8-mil aluminum tape applied longitudinally with overlap. Shield interfaces shall be flooded.

3. Jacket: A marked, black, low-density polyethylene jacket applied overall.
- E. Building Entrance Surge Suppression Panels: Multi-pair protector panels for building entrance cable surge suppression. Panels shall utilize industry standard 5-pin protector modules. Provide panel with solid-state protector modules.
- F. Voice Cross-Connect/Patch Panel: Modular panels housing multiple jack units with Category 6 compliant IDC-type connectors at each jack for permanent termination of pair groups of installed horizontal cables. Jacks shall be configured in replaceable modular groups of six jacks each.
 1. Number of Jacks supported per Field/Panel: **24 Port (1U) or 48 Port (2U)** depending on riser cable pair count.
 2. Terminate riser cable one pair per port on cross-connect/patch panel.
 3. Mounting: Rack.

2.6 OPTICAL FIBER RACEWAY

- A. Flexible telecommunication raceway (innerduct) designed and listed specifically for use with fiber optic cables. All innerduct installed shall be UL listed Plenum rated. General rated will NOT be allowed. UL label must be stamped or printed on product. Only fiber optic cable shall be installed in this raceway. All optical fiber raceway shall have a diameter of 1" minimum. All optical fiber raceway shall be connected together or to boxes with fittings specifically designed to match raceway. Electrical tape will not be accepted as a method of joining raceway.

2.7 FIBER-OPTIC CABLES, CONNECTORS, AND TERMINAL EQUIPMENT

- A. Contractor has the option to provide interlocking armored fiber (plenum rated) instead of standard fiber and innerduct.
- B. Single mode Cables: Factory fabricated, jacketed, low loss, glass type, fiber optic, single mode, graded index, operating at 1320 and 1350nm.
 1. Strands per Cable: See plans.
 2. All Cables installed inside building must be plenum rated type OFNP, complying with NFPA 262.
 3. Color coded: Yellow
 4. Dimensions: 8.7-micrometer core diameter; 125-micrometer cladding diameter.
 5. Maximum Attenuation: 1.0 dB/km at 1310 nm; 0.75 dB/km at 1550 nm.
 6. Operating Temperature Range: Minus 20 to plus 70 deg C.
- C. Multimode Cables: Factory fabricated, jacketed, low loss, glass type, fiber optic, OM3 laser optimized multimode, graded index, operating at 850 and 1300 nm.
 1. Strands per Cable: See plans.
 2. All Cables installed inside building must be plenum rated type OFNP, complying with NFPA 262.
 3. Color coded: Aqua

4. Dimensions: 50.0-micrometer core diameter; 125-micrometer cladding diameter.
 5. 10 Gigabit Ethernet Distance: 300m at 850 nm; 300m at 1310 nm.
 6. Maximum Attenuation: 2.3 dB/km at 850 nm; 0.6 dB/km at 1300 nm.
 7. Minimum Effective Modal Bandwidth: 2000 MHz*km at 850 nm; 500 MHz*km at 1300 nm.
 8. Operating Temperature Range: Minus 20 to plus 70 deg C.
- D. Hybrid Single-Mode/Multimode Cables: Single-jacket cable comprised of both single-mode and multi-mode fibers.
1. See paragraphs above for fiber optic cable requirements.
 2. Jacket: Aqua, flame resistant outer jacket.
- E. OSP Hybrid Single-Mode/Multimode Cables: Loose tube, gel-filled construction with single-jacket cable comprised of both single-mode and multi-mode fibers.
1. See paragraphs above for fiber optic cable requirements.
 2. Jacket: Marked, black UV- and moisture-resistant polyethylene jacket
- F. Cable Connectors: Ceramic ferrule with composite hardware, ST connectors with self-centering, axial alignment mechanisms. Insertion loss not more than 0.20 dB. Provide rubber or plastic boot for strain relief.
- G. Rack Mounted fiber enclosures: Modular panels housing multiple-numbered, duplex cable connectors.
1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, blank positions populate with 6-fiber, ST duplex multimode adapter panels.
 2. Modular enclosure with retainer rings in the slack storage section to limit the bend radius of fibers.
 3. Provide a 'window' section to insert fiber optic panels for mounting adapters.
 4. Fiber enclosures shall contain no patch cable in IDF's. Contractor shall connect backbone fiber in rear of enclosure and two strand fibers in front of enclosure using 'bulkhead connectors to achieve pass through of the fiber.

2.8 WIRE MANAGEMENT PANELS

- A. Provide vertical wire management for each rack in Telecom room. Provide two per rack. Vertical members shall have the capacity for 480 Category 6 cables and have metal hinged doors.
- B. Provide horizontal wire managements panels, (install one per patch panel).

2.9 IDENTIFICATION PRODUCTS

- A. Cable Labels: Vinyl wraparound tape markers, machine printed with alphanumeric cable designations. Covered with clear shrink wrap. Use of clear tape is unacceptable.

- B. Outlet and Patch Panel Labels: Vinyl permanent, non-erasable, stick-on, labeling using a professional labeling machine.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 RACEWAY INSTALLATION

- A. All 2" or larger conduit and sleeves:
 - 1. A pullbox sized per BICSI's *Telecommunications Distributions Methods Manual* must be provided after every 180° of bend or in straight section exceeding 150' in length.
 - 2. All bends must utilize manufactured sweeping long-radius elbows.
 - 3. Provide bushings and marked pull tape for all.
- B. All outlet box conduits shall be routed to cable tray utilizing no more than 180° of bend without intermediate junction box. All such junction boxes shall be located in accessible ceilings and shown on As-Built.

3.3 APPLICATION OF MEDIA

- A. Interbuilding Backbone Cable to Data Service: Use OSP hybrid single- and multi-mode fiber-optic cable for all cabling extending outside of the building in which it originates.
- B. Interbuilding Backbone Cable for Auxiliary Voice Service: Use OSP/Flooded cable for all auxiliary voice cabling extending outside of the building in which it originates. Terminate in building entrance surge suppression panels and extend to voice cross-connect fields.
- C. Horizontal Cable for Copper Voice (over IP) Service: Use UTP Category 6 cable for runs between workstation outlets and Telecom rooms (IDFs). Terminate horizontal cable in dedicated Voice (over IP) rack-mounted patch panels.
- D. Horizontal Cable for Copper Data Service: Use UTP Category 6 cable for runs between workstation outlets and Telecom rooms (IDFs). Terminate horizontal data cable in rack-mounted patch panels.
- E. Horizontal Cable for Copper Security Camera Service: Use UTP Category 6 cable for runs between camera locations and Telecom rooms (IDFs). Terminate horizontal cable in dedicated Security Camera rack-mounted patch panels.

3.4 INSTALLATION

- A. Each wiring system, Voice (over IP), Data and Security Camera shall be mounted on separate patch panels within each rack/cabinet.
- B. Data jacks shall be terminated using TIA/EIA 568B color coding.
- C. Wiring Method: Install control wiring in raceway where concealed within walls, concealed above inaccessible ceilings, and where exposed. In accessible ceiling spaces provide Innerduct for fiber and all copper to be supported by J-hooks. Conceal raceway and cables except in unfinished spaces.
- D. Install cables using techniques, practices, and methods that are consistent with Category 6 rating of components, and that ensure Category 6 performance of completed and linked signal paths, end to end.
- E. Install cables without damaging conductors, shield, or jacket. Visible jacket stress is considered damage. Engineer to have final word on cable damage. Damaged cables shall be replaced.
- F. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.
- G. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
 - 1. Pull cables simultaneously if more than one is being installed in same raceway.
 - 2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
 - 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces or exposed structural members and follow surface contours where possible.
- I. Provide 4' service loop for all copper cables in outlet at conduit stub-up. Provide 10' service loop for all copper cables in ladder rack above equipment rack/cabinet in IDF/MDFs.
- J. Secure and support cables at intervals not exceeding 60 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- K. All cables shall be secured using Velcro fasteners or "ty-wraps". If "ty-wraps" are used, they shall not be pulled tight. All "ty-wraps" must freely rotate around bundled cable and shall be plenum rated and meet the flame and smoke characteristics listed in paragraph 1.6 QUALITY ASSURANCE.
- L. Wiring within Wiring Closets and Enclosures: Provide conductors of adequate length. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

1. Slack optical fiber shall be neatly coiled within the fiber termination panel. No slack loops shall be allowed external to the fiber panel(s).
- M. Separation of Wires: Comply with TIA/EIA-569-A rules for separating unshielded copper voice and data communication cabling from potential EMI sources, including electrical power lines and equipment.
- N. Make splices, taps, and terminations only at indicated outlets, terminals, and cross-connect and patch panels.
- O. Use splice and tap connectors compatible with media types.
- P. Contractor to terminate the voice backbone cables on 66 blocks.

3.5 GROUNDING

- A. Ground equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Telecom Room Grounding: Provide Telecommunication Grounding Busbar and Telecommunication Bonding Backbone as shown on plans.

3.6 INSTALLATION IN EQUIPMENT ROOMS AND WIRING CLOSETS

- A. Group connecting hardware for cables into separate logical fields.
- B. Use patch panels to terminate cables entering the space, unless otherwise indicated.

3.7 INSTALLATION STANDARDS

- A. Comply with requirements in TIA/EIA-568-A and TIA/EIA-569-A.
- B. Comply with requirements in TIA/EIA-560-A standards.

3.8 IDENTIFICATION

- A. System: Use a unique, three-syllable, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with same designation. Use logical and systematic designations for facility's architectural arrangement.
 1. Example Label: HO-IT105-D32
 2. First syllable identifies the building: (HO) Holding Hall
 3. Second syllable identifies room in which cables terminate. (IT105)
 4. Third syllable designates type of use (data, data, voice) and position occupied by cable pairs in field. Data port -A-1, Data port -B-1, Voice port C-1.

- B. Workstation:
 - 1. Label cables within outlet boxes.
 - 2. Label each port in workstation faceplate. Utilize labeling slots at the top and bottom of faceplate.
- C. Distribution Racks and Frames: Label each unit and field within that unit.
- D. Within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- E. Cables, General: Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 1. Labeling of cables at patch panel shall be applied such that label is visible without removing the bundle support ties. Cables labeled within the bundle, where the label is obscured from view shall not be acceptable.
- F. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project, in software and format selected by Owner.
- G. Cable Administration Drawings: Show building floor plans with cable administration point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606. Furnish electronic record of all plan drawings, in AutoCAD software or newer versions.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
 - 2. Copper Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Test according to TIA/EIA-TSB67, "Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems". Link performance for UTP cables must meet minimum criteria of TIA/EIA-568-A.

3. Fiber-Optic Cable Procedures: Perform each visual and mechanical inspection. Fiber Optic Cables shall be tested in Accordance with EIA/TIA 568A- Annex H. **Maximum db loss shall be 2.0 for all fiber cables.** Certify compliance with test parameters and manufacturer's written recommendations. Test optical performance with optical power meter capable of generating light at all appropriate wavelengths.
 4. All cable identifications listed on test data must match the cable identifications of the labels installed on the face plates and patch panels.
- C. Remove malfunctioning units, replace with new units, and retest as specified above.
- D. Reporting: Provide both hard copy and electronic copy of all unacceptable and final acceptable test results as directed in SUBMITTALS paragraph.

END OF SECTION 267500

SECTION 268311**FIRE ALARM****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 SCOPE

- A. This section of the specifications includes the furnishing, installation, and connection of the microprocessor controlled, addressable/intelligent reporting fire alarm equipment required to form a complete coordinated system ready for operation. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panels, auxiliary control devices, annunciators, power supplies, and wiring as shown on the Drawings and specified herein. Relevant criteria from the North Carolina Department of Insurance's *Fire Detection and Alarm Guidelines* have been incorporated within this Section.
- B. Fire Alarm system equipment, including supporting raceway, requires Seismic Controls. Equipment is required to be certified by the manufacturer. Engineer has delegated design of controls for mounting and supports to Contractor.
 - 1. Delegated Design: Design fire alarm system equipment supports, mounting, and associated raceway supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 2. Seismic Performance: Fire alarm system equipment shall withstand the effects of earthquake motions determined according to ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".
 - 3. Structural Performance: Fire alarm system equipment supports, mounting, and associated raceway supports shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE 7.
 - a. Seismic Loads: Refer to Specification Section 260548.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled. All products, including initiating devices and notification

appliances, shall be as produced or supplied by the same manufacturer as the fire alarm control panel. Products of firms that do not maintain factory authorized service organization and spare parts stock are not acceptable for use on this project.

- B. **Installer Qualifications:** An experienced Installer who is an authorized representative of the FACP manufacturer for both installations and maintenance of all equipment required for this Project. The Installer technicians shall be individually certified NICET Level 2 and by the manufacturer of the equipment and trained and certified on the specific model being installed. Installer shall have at least one technician on staff certified NICET Level 3. Certification shall be current to latest release and must have occurred in the most recent 24 months. All connections to the FACP and the systems programming shall be completed only by Installer technicians compliant with qualifications. Copies of certifications shall be submitted with shop drawings.
- C. **Codes and Standards:**
 - 1. **NFPA Compliance:** Comply with applicable requirements of NFPA-72, National Fire Alarm Code.
 - 2. **NEC Compliance:** Comply with applicable requirements of NFPA-70, National Electrical Code (NEC) standards pertaining to fire alarm systems.
 - 3. **Testing Laboratory Compliance:** Comply with provisions of UL safety standards pertaining to fire alarm systems. Provide products and components which are Listed and Labeled.
 - 4. **FM Compliance:** Provide fire alarm systems and accessories which are FM approved.
 - 5. **State Building Code Compliance:** Comply with applicable requirements of South Carolina State Building Code.
 - 6. **Fire Marshall Compliance:** Provide fire alarm systems and accessories which are Fire Marshall approved.
 - 7. **Comply with Authority Having Jurisdiction.**

1.4 SUBMITTALS - GENERAL

- A. Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification. Where a submitted item does not comply fully with each and every requirement of the specifications, the submittal shall clearly indicate such deviations. Identification requirements for non-complying features of items are very specific.
 - 1. **Installer Certifications:** Copies of manufacturer signed certifications and NICET certifications as required above.
 - 2. **Product Data:** Submit Manufacturer's technical product data, including specifications and installation instructions, for each type of fire alarm system equipment.
 - 3. **Battery Sizing Calculations.** Also submit voltage drop and current draw calculations for control panel and NAC panels.
 - 4. **Shop Drawings:** Submit (2) bound full size sets of shop drawings showing equipment, device locations, and connecting wiring of entire fire alarm system depicted on scaled architectural floor plans with Installer's border sheet. Include wiring and riser diagrams and battery calculations. Provide distance and

proposed route for each notification appliance circuit. Devices shall include proposed address label. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with most recent release of AutoCAD upon request. Copies of Project Construction Documents or details there from may NOT be a part of the shop drawing submittal.

5. Authority Having Jurisdiction Submittal: Submit (1) one copy of Product Data and Shop Drawings as specified above to Authority Having Jurisdiction. Engineers shall review and approve shop drawings in SC. Resubmit if required to make clarifications or revisions to obtain approval.
6. Maintenance Data: Submit maintenance data and parts lists for each type of fire alarm equipment installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual.
7. As-Built: Submit (3) three bound full size sets of scaled architectural floor plans depicting final device and equipment locations, all circuiting, and pathway and terminal cabinet locations. Include wiring and riser diagrams with battery calculations based off of installation. Also submit (3) copies of Product Data, Installation Instructions, Device Address List, System Matrix, System Status and Programming Report and all other pertinent information specified elsewhere within document.
8. Test Reports: Submit a letter and a copy of the test report indicating proper functioning of the system, and conformance to the requirements of the Contact Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, the manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Edwards Systems Technology (EST).
 2. Gamewell/Fire Control Instruments, Inc.
 3. Notifier; Honeywell International, Inc.
 4. Siemens Fire Safety.
 5. Simplex-Grinnell.

2.2 FIRE ALARM CONTROL PANEL (FACP)

- A. General: The FACP shall meet the following general requirements:
 1. Signal Line Circuits: Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto an NFPA Style 6 (Class A) Signaling Line Circuit (SLC).
 2. Initiation Device Circuits: Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
 3. Notification Appliance Circuits: Notification appliance circuits shall be wired Class B (NFPA Style Y).

4. Digitized electronic signals shall employ check digits or multiple polling. In general a single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 5. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
 6. System Response to an Alarm Condition: When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - a. The system alarm LED shall flash. A local piezo-electric signal in the control panel shall sound.
 - b. The 80-character LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
 - c. On systems equipped with a printer, printing and history storage equipment shall log the information associated each new fire alarm control panel condition, along with time and date of occurrence.
 - d. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated. Exact programming shall be provided by the Contractor to meet the Owners requirements.
 - e. Activate all alarm notification appliances in the building, sounding and flashing in synchronization continuously until manually silenced, or until the initiating device and control unit have been reset to normal condition.
 - f. Activate digital alarm communicator.
 - g. Deactivate door hold control relay such that all smoke doors are allowed to close.
 - h. Activate elevator recall sequence if smoke is detected in any elevator lobby or in the elevator equipment room.
 7. System Response to a Trouble Condition:
 - a. System AC power trouble signal shall not be sent unless maintained for 8 hours (or more).
 - b. Provide adjustable time delay for all trouble signals prior to transmission.
 - c. Default setting shall be immediate transmission for all supervising signals.
- B. FACP - Minimum Requirements: The FACP shall contain a microprocessor based Central Processing Unit (CPU). The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, local and remote operator terminals, printers, annunciators, and other system controlled devices. The main FACP shall perform the following functions:
1. Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
 2. Supervise all initiating, signaling, and notification circuits throughout the facility by way of connection to monitor and control modules.
 3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.

4. Visually and audibly annunciate any trouble, supervisory or alarm condition on operator's terminals, panel display, and annunciators.
- C. System Capacity and General Operation: The system shall have the following capacities and general operation modes:
1. The FACP shall be capable of connecting to the number of devices shown on drawings or capable of expansion to 198 intelligent/addressable devices per SLC and 2048 annunciation points per system, whichever is greater. The number of SLCs provided shall be as indicated on the Drawings. Each SLC shall not carry more than 75% of its load capacity.
 2. The FACP shall include a full featured operator interface control and annunciation panel that shall include a backlit, 80 character liquid crystal display, individual, color coded system status LEDs, and an alphanumeric keypad for the field programming and control of the fire alarm system.
 3. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
 4. The FACP shall be able to provide the following features:

Upload/Download to PC Computer	Charger Rate Control
Alarm Verification with Tally	Drift Compensation
Automatic Day/Night Sensitivity Adjust	Device Blink Control
Pre-alarm Control Panel Indication	Trouble Reminder
NFPA Smoke Detector Sensitivity Test	Walk Test
System Status Reports	Periodic Detector Test
Alarm Verification, by device, with tally	Multiple Printer Interface
Multiple CRT Display Interface	Security Monitor Points
Non-Alarm Module Reporting	Block Acknowledge
Smoke Detector Maintenance Alert	Control-By-Time
- D. Central Processing Unit: The Central Processing Unit (CPU) shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the CPU.
1. The CPU shall contain and execute all control-by-event (including ANDing, ORing, NOTing, CROSSZONEing) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost with system primary and secondary power failure. The CPU shall also provide a real-time clock for time annotation of all system displays. The Time-of-Day and date shall not be lost if system primary and secondary power supplies fail.
 2. The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
 3. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients consistent with UL standard 864. □ □
- E. Display: The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.

The display assembly shall contain, and display as required, custom alphanumeric labels for all intelligent detectors, addressable modules, and software zones.

1. The system display shall provide an 80-character back-lit alphanumeric Liquid Crystal Display (LCD). It shall also provide five Light-Emitting-Diodes (LEDs), that will indicate the status of the following system parameters: AC POWER, SYSTEM ALARM, SYSTEM TROUBLE, DISPLAY TROUBLE, and SIGNAL SILENCE.
 2. The system display shall provide a 25-key touch key-pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels shall be accessible through the display interface assembly to prevent unauthorized system control or programming.
 3. The system display shall include the following operator control switches: SIGNAL SILENCE, LAMP TEST, RESET, and ACKNOWLEDGE.
- F. Signaling Line Circuit (SLC) Interface Board: The FACP shall contain SLC interface boards as required to communicate with the SLC loops as shown on the Drawings. Each SLC board shall monitor and control a minimum of 198 intelligent addressable devices. This includes 99 analog detectors (Ionization, Photoelectric, or Thermal) and 99 monitor or control modules.
1. Each SLC interface board shall contain its own microprocessor, and shall be capable of operating in a local mode (any SLC input activates all or specific SLC outputs) in the event of a failure in the main CPU of the control panel. The SLC interface board shall not require any jumper cuts or address switch settings to initialize SLC Loop operations. SLC interface boards shall provide power and communicate with all intelligent addressable detectors and modules connected to it's SLC Loop on a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
 2. Each SLC interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The SLC interface board software shall include software to automatically maintain the detector's desired sensitivity level by adjusting for the effects of environmental factors, including the accumulation of dust in each detector. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
- G. Serial Interface Board: The FACP shall contain a serial interface board to provide an EIA-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals. The serial interface board shall allow the use of multiple printers, CRT monitors, and other peripherals connected to the EIA-232 ports. In addition, the serial interface board shall provide one EIA-485 port for the serial connection to annunciation and control subsystem components; LEDs shall be provided to show operational status. All serial interface input/outputs shall be optically isolated to provide protection from surges and/or earth grounds.

- H. Operators Terminal: Provide an operators terminal which allows the following minimum functions. In addition, the operators terminal shall support any other functions required for system control and/or operation:
1. Acknowledge (ACK/STEP) Switch
 2. Signal Silence Switch
 3. System Reset Switch
 4. System Test Switch
 5. Lamp Test Switch
- I. Printer: Provide a printer to provide hard-copy printout of all changes in status of the system. The printer shall time-stamp such printouts with the current time-of-day and date. The printer shall be standard carriage with 80-characters per line and shall use standard pin-feed paper. Thermal printers are not acceptable. The printer shall operate from a 120 VAC, 60 Hz power source. Provide printer stand compatible with printer style indicated.
- J. Remote Transmissions: The FACP shall be interfaced to a NFPA 72 type, multi-channel Digital Cellular Communicator (DCC) for transmission of its fire alarm, supervisory, and trouble signals to the Owner's designated receiving station. Provide a DCC which is fully compatible and is capable of proper call in, signal exchange and disconnect with the receiving equipment. DCC shall be provided with integral rechargeable batteries with automatic charger. Unit shall perform a self-test once every 24 hours. Failure shall initiate a local trouble. Loss of primary or alternate channel shall initiate a local trouble. Trouble signal for AC power loss must not be sent unless maintained for 6 hours or more. The following signals, in order of precedence shall be reported as applicable:
1. Fire.
 2. Waterflow.
 3. Supervisory.
 4. Trouble.
- K. Power Supply: The FACP power supply(ies) shall operate on 120 VAC, 60 Hz circuit with dedicated ground and shall have a continuous rating adequate to power all equipment and functions in full alarm continuously. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. Further, the power supply shall be expandable for additional notification appliance power in 3.0 Ampere increments.
1. The power supply shall provide a battery charger for 60 hours of standby using dual-rate charging techniques for fast battery recharge.
- L. Emergency Power Supply: Components include batteries, charger, and an automatic transfer switch.
1. Batteries. Sealed maintenance-free lead calcium construction with fully gelled electrolyte.
 - a. Battery Nominal Life Expectancy: 15 years, minimum.
 - b. Battery Capacity: Comply with NFPA 72. Under maximum quiescent load (system functioning in a non-alarm condition), the secondary supply shall have sufficient capacity to operate the entire system for 60 hours; and at

- the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of the emergency for 5 minutes.
- c. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.
 - d. Battery Calculations: Calculations must be based on the most distant notification appliance on each circuit such that the voltage level at the end of 60 hours of monitor and 5 minutes of alarm is greater than the listed minimum operating voltage for that appliance.
- 2. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
 - 3. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.
- M. Enclosures: The FACP shall be housed in a UL listed cabinet suitable for surface or semi-flush mounting. Cabinet and front shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators. For convenience, the door may be hinged on either the right or left side (field selectable).

2.3 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
- B. Horns shall be located as shown on the Drawings; horns located outdoors shall be listed for use in wet locations. Horns shall have the following specifications:
 - 1. Voltage: Horns shall operate on 24 VDC nominal.
 - 2. Programming: Horns shall be field programmable without the use of special tools, to provide slow whoop, continuous, or interrupted tones with an output sound level between a minimum of 90 dBA and a maximum of 120 dBA measured at 10 feet from the device.
 - 3. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.
- C. Strobe Lights shall be located as shown on the Drawings. Strobe lights indicated for use at exterior of the building shall be mounted at the indicated elevation and listed for use in wet locations. Strobe lights shall have the following specifications:
 - 1. Voltage: Strobe lights shall operate on 24 VDC nominal.
 - 2. Programming: Strobes shall field programmable without the use of special tools to provide 15/75, 30, 75, and 110 Candela output.

3. Maximum pulse duration: 2/10ths of one second.
 4. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.
 5. Strobe intensity and flash rate: Must meet minimum requirements of UL 1971. Provide strobe lights with specific intensity Candela (Cd) rating if such is indicated adjacent to the device symbol on the Drawings.
 6. Strobes shall be synchronized
- D. Audible/Visual Combination Devices shall be located as shown on the Drawings and shall comply with all applicable requirements for both Horns and Strobe Lights. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.

2.4 INITIATING DEVICES

- A. Addressable Devices - General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. Addressable devices shall comply with the following requirements:
1. Address Setting: Addressable devices shall provide an address-setting means that use rotary decimal switches configured to provide decade (numbered 1 to 10) type addresses.
 2. Connections: Addressable devices shall be connected to a Signaling Line Circuit (SLC) with two (2) wires. Signaling Line Circuits shall originate as indicated on the Riser Diagram shown in the Drawings.
 3. Operational Indications: Addressable initiation devices shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions, indicating that the device is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the FACP to indicate that an alarm condition has been detected. The flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the device base to connect an external remote alarm LED.
 4. Intelligent Initiation Devices: All smoke detectors shall be the "intelligent" in that smoke detector sensitivity shall be set through the FACP and shall be adjustable in the field through the field programming of the system. Sensitivity shall be capable of being automatically adjusted by the FACP on a time-of-day basis. Using software in the FACP, detectors shall be capable of automatically compensating for dust accumulation and other slow environmental changes that may affect performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter.
 5. Device mounting Base: Unless otherwise specified all detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature.
 6. Sounder Base: Where indicated on the Drawings, provide bases with a built-in (local) sounder rated at 85 dBA minimum. Configure sounder bases such that sounders are activated under conditions as described or otherwise indicated on the Drawings.

7. Test Means: The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel when in the "test" condition.
 8. Device Identification: Detectors shall store an internal identifying type code that the control panel shall use to identify the type of device. Device identifications shall be either PHOTO or THERMAL.
- B. Pull Stations: Addressable type, pull stations shall, on command from the Control Panel, send data to the panel representing the state of the manual switch. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Pull stations that employ a glass break rod are not acceptable.
1. Pull stations shall have a dual-action mechanism requiring two actions to initiate alarm.
 2. All pull stations shall have a positive, visual indication of operation and utilize a double pole, double throw key type reset.
 3. Construction: Pull stations shall be constructed of Lexan or other material suitable to the installation environment with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans. Mount devices at heights indicated on plans.
 4. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
- C. Photoelectric Smoke Detectors: Photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density. Unless otherwise indicated on the Drawings all smoke detectors shall be photoelectric type.
1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
- D. Thermal Detectors: Thermal Detectors shall be intelligent addressable devices rated at 200°F. (93° C.) and unless otherwise indicated on the Drawings shall have a rate-of-rise element rated at 15° F. (9.4° C.) per minute. Thermal detectors shall use an electronic sensor to measure thermal conditions caused by a fire and shall, on command from the control panel, send data to the panel representing the analog level of such thermal measurements.
1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.

- E. Non-Rate of Rise Detectors: Where indicated on the Drawings provide thermal detectors with non-rate of rise thermal elements. Non-rate of rise detectors are indicated by NRR adjacent to the thermal detector symbol.
- F. Duct Smoke Detector: In-Duct Smoke Detector Housings shall accommodate either an intelligent ionization sensor or an intelligent photoelectric sensor as described elsewhere. The device, independent of the type used, shall provide continuous analog monitoring and alarm verification from the panel. When sufficient smoke is sensed, an alarm signal shall be initiated at the FACP. Unless otherwise indicated on the Drawings all duct smoke detectors shall be photoelectric type
 - 1. Installation: Duct detectors and related items shall be furnished and connected by the Division 26 (Electrical) Contractor but installed by the Division 23 (Mechanical) Contractor.
 - 2. Each duct detector installation shall have a hinged or latched access panel, 12"x12" minimum, for sampling tube inspection and cleaning. Coordinate with Mechanical Contractor.

2.5 MISCELLANEOUS SYSTEM ITEMS

- A. Addressable Dry Contact Monitor Module: Addressable Monitor Modules shall be provided to connect one supervised IDC zone (either Style D or Style B) of conventional Alarm Initiating Devices (any Normally Open [N.O.] dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.
 - 1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
 - 2. Mounting Requirements: Monitor Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
 - 3. Location Requirements: Monitor Modules shall be located within conditioned space.
- B. Two Wire Detector Monitor Module: Addressable Monitor Modules shall be provided to connect one supervised IDC zone, either Class A or B (Style D or Style B operation) of conventional 2- wire smoke detectors or alarm initiating devices (any N.O. dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.
 - 1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the control panel.
 - 2. Mounting Requirements: Monitor Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
 - 3. Location Requirements: Monitor Modules shall be located within conditioned space.

- C. Addressable Control Module: Addressable Control Modules shall be provided to supervise and control the operation of one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized Audio/Visual (A/V) Notification Appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay. The control module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. An LED shall be provided that shall flash under normal conditions, indicating that the control module is operational and is in regular communication with the control panel.
1. Mounting Requirements: Control Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical boxes.
 2. Configuration: The control module NAC circuit may be wired for Style Z or Style Y (Class A/B) with up to 1 Amp of inductive A/V signal, or 2 Amps of resistive A/V signal operation, or as a dry contact (Form C) relay. The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
 3. Location Requirements: Monitor Modules shall be located within conditioned space.
 4. Power Source: Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply. A/V power sources and connections are not shown on the Drawings.
 5. Test Switch: A magnetic test switch shall be provided to test the module without opening or shorting its NAC wiring.
- D. Isolator Module: Isolator Modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop.
1. Operation: Isolator Modules shall operate such that if a wire-to-wire short occurs, the Isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section. The Isolator Module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.
 2. Mounting: The Isolator Module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.
 3. Isolation Modules shall be mounted at the same height as required for A/V devices.
- E. Remote Display Annunciator: The Alphanumeric display annunciator shall be a supervised, remotely located back-lit LCD display containing a minimum of eighty (80) characters for alarm annunciation in clear English text. The LCD annunciator shall display all alarm and trouble conditions in the system and duplicate manual switching

functions of the FACP, including acknowledging, silencing, reset, and test. The remote annunciator shall also have a LED graphic display panel mounted adjacent to the LCD display.

1. System Capacity: The system shall allow a minimum of four LCD annunciators. In addition to annunciation functions, each LCD annunciator shall be capable of the following software programmed system functions: Acknowledge, Signal Silence and Reset.
 2. Connections: The annunciator shall connect to a two-wire EIA-485 interface. The two-wire connection shall be capable operation at distances of 6,000 feet. Provide interface to fiber optic cable systems and/or repeater units where such are indicated on the Drawings.
 3. Protection: The annunciator shall be outfitted with a full Lexan cover on hinged door with locking key access.
- F. Zone Map: Zone maps shall show entire building layout with initiating devices, remote annunciators, and FACP. Room numbers shall reflect actual building signage, not architectural room numbers. Zone maps shall be large enough scale to read device labels easily and clearly. Do not display notification appliances on zone maps.
- G. Remote Annunciator Indicator Lights (RAIL): Remote annunciator indicator lights shall be provided in locations where indicated on the Drawings. RAILS shall be provided with a key type switch for testing of the annunciated device. In addition, RAILS shall have the following features:
1. Voltage: RAILS shall operate on 24 VDC nominal.
 2. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Unless otherwise indicated on the Drawings, RAILS shall be mounted as described for electronic sounders above.
- H. TVSS: The system shall be equipped with the following protective devices to prevent damage or nuisance alarms by nearby lightning strikes, stray currents, or voltage transients. The devices are to be provided by the fire alarm equipment supplier:
1. On AC Input: A feed-through (not a shunt-type) branch circuit transient arrestor such as the EFI HWM-120, Leviton OEM-120EFI, Northern Technologies DMK-B, Transtector ACP100BWN3, or equivalent UL Listed device by Square-D or EIT. Install in a listed enclosure near the electrical panelboard and trim excess lead lengths. Wind small coil in the branch circuit conductor, within panelboard, downstream of the suppressor connection. Coil is to be about 1" diameter, 5 to 10 turns, and tie-wrapped.
 2. On DC Circuits Extending Outside Building: Adjacent to the FACU, and also near point of entry to outlying building, provide "pi"-type filter on each leg, consisting of a primary arrestor, series impedance, and a fast acting secondary arrestor which calmps between 30 and 40 Volts. Acceptable models include Innovative Technology D2S33-2ML, Simplex 2081-9027 and 2081-9028, Transtector TSP8601, Ditek DTKxLVL series, Citel America B280-24V, and Northern Technologies DLP-42, or equivalent by Square-D or EIT.
- I. Wire

1. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, THHN/THWN, color-coded insulation.
 - a. Low-Voltage Circuits: No. 18 AWG, minimum.
 - b. Line-Voltage Circuits: No. 12 AWG, minimum.
2. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer. Data Loop wire shall be shielded pair #18 AWG, 30 pf/ft capacitance or less, unless specifically prohibited by the equipment manufacturer and stated on the wiring submittal

PART 3 - EXECUTION

3.1 FIRE ALARM SYSTEM INSTALLATION AND CONFIGURATION

- A. Installation of the FACP and connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.
 1. All connections at the FACP must be made by the Manufacturer's authorized, factory trained representative (rather than by the electrical contractor).
- B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
 1. All system components shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load. Adhesives are not permitted to mount fire alarm system components to building surfaces or structure.
- C. Circuit Breaker serving FACP shall be lockable and locked in the "ON" position.
- D. All addressable loop controller circuits must be "Class A" and shall have a minimum of 20% spare addresses for future use. "T-taps" from the loop are not permitted. To minimize the impact of a wiring fault on the system, isolation modules must be provided as follows:
 1. For each circuit extending outside the building.
 2. Within 15 feet of the FACP, at each end of the loop.
 3. At the Terminal Cabinet, at each end of the loop.
 4. Minimal of (1) midway through the loop address scheme. Additional modules shall be provided after each 25 devices or control points on each addressable circuit.
 5. Isolation modules not located at the FACP shall be mounted readily visible in unfinished spaces (i.e. electrical rooms, mechanical rooms, and janitorial closets) only at same height as audio/visual devices.
- E. Manual Pull Stations shall be mounted semi-flush within recessed back boxes

- F. Visible signals must be the strobe (flash discharge) type, with white or clear lens, and shall comply with current ADA requirements for intensity, placement, and synchronization.
- G. The FACP must have an Alarm Silence switch, and be equipped with the Subsequent Alarm (alarm resound) feature. Any remote annunciators or graphic displays located away from the alarm area must also include an audible signal with alarm resound feature.
1. Alarm Silence shall not reverse AHU shutdown and disable smoke evacuation system. Provide supervised Hand-Off-Auto switches at the FACP for any smoke control equipment.
- H. All supervisory trouble signals shall be different and distinct from a normal system trouble and shall be non-silenceable.
- I. Provide a supervised "AHU Shutdown Defeat" toggle switch in the FACP. Provide an informative engraved label at switch indicating "Normal" position. The switch must cause a system "trouble" indication when it is placed in the off ("Shutdown Defeated") position.
- J. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated.
1. The exterior of all junction boxes containing fire alarm conductors shall be painted red; box interiors shall not be painted. Box covers for junction boxes containing fire alarm conductors shall be painted red on both sides. All painting of junction boxes and junction box covers shall be accomplished prior to installation of the boxes to avoid possible problems with overspray.
 2. Box covers shall be labeled to indicate the circuit(s) or function of the conductors contained therein. Labels shall be neatly applied black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.
 3. Provide metal back boxes or plastic skirts as manufactured by fire alarm manufacture for devices installed in a surface mounted application. Boxes shall match device in size and color.
- K. All wiring shall be color coded in accordance with the following scheme, which shall be maintained throughout the system, without color change in any wire run:
- | | |
|-----------------------------|---|
| Signaling Circuits | Overall Red Sheath, Red (+) and Black (-) |
| Alarm Notification Circuits | Blue (+) and Black (-) |
| 24V System Circuits (HVAC) | Yellow (+) and Brown (-) |
| Elevator Capture Circuits | Yellow (+) and Brown (-) |
| Door Control Circuits | Orange |
- L. Cable Splices: Any and all cable splices shall be in hinged terminal cabinets only. No splicing of conductors in outlet or junction boxes. There shall be NO splices in the system other than at terminal blocks. "Wire nuts," crimp splices, or insulation piercing type connectors are not acceptable. All terminal block screws shall have pressure wire

connectors of the self-lifting or box lug type. Permanent wire markers shall be used to identify all splices and terminations for each circuit. For splices, use markers or other means to indicate which conductors leads to the FACP.

- M. Detection or alarm circuits shall not be installed in raceways containing AC power or AC control wiring. Within the FACP, any 120 VAC control wiring or other circuits with an externally supplied AC/DC voltage above the nominal 24 VDC system power must be properly separated from other circuits and the enclosure must have an appropriate warning label to alert service personnel to the potential hazard.
- N. Provide an engraved label on FACP and all notification appliance circuit expansion panels identifying its 120 VAC power source. This label shall include panelboard identification and circuit number and panelboard location.
- O. All wiring shall be checked for grounds, opens, and shorts, prior to termination at panels and installation of detector heads. The minimum resistance to ground or between any two conductors shall be ten megohms (10 M Ω), as verified with a megger. Provide advance notice to the Engineer of these tests.
- P. The system shall be electrically supervised for open or (+/-) ground fault conditions in SLC, alarm circuits, and control circuits. Removal of any detection device, alarm appliance, plug-in relay, system module, or standby battery connection shall also result in a trouble signal. Fire alarm signal shall override trouble signals, but any pre-alarm trouble signal shall reappear when the panel is reset.
- Q. Supervision required: The connection between individual addressable modules and their contract type initiating device(s) must be supervised.
- R. Spare Parts: Provide the following spare parts with the system, each individually packaged and labeled. For percentage quantities round number up to the next larger whole number.

Fuses	(2) of each size used in the system
Indoor Speaker/Strobes	4% of installed quantity
Exterior Indicating Devices	4% of installed quantity
Spot Smoke Detectors	6% of installed quantity
Spot Heat/Thermal Detectors	6% of installed quantity
Spot Smoke Detectors, Bases	2% of installed quantity
Relay Modules	4% of installed quantity
Monitor Modules	4% of installed quantity
Isolation Modules	4% of installed quantity
Isolation Bases	4% of installed quantity
Manual Stations	2% of installed quantity

3.2 SMOKE DETECTORS

- A. Do not install detector heads until building is clean. Provide dust covers for bases throughout construction. Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed.

Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.

- B. A spot type smoke detector shall be provided within 15' from FACP, auxiliary panels, power extenders, NAC expansion panels and other control equipment. As NAC expansion panels and power extenders are not shown on drawings, additional detectors not shown shall be added required to meet this provision.
- C. When installed in a room, detectors shall be oriented so their alarm light is visible from the nearest door to the corridor, unless Remote Alarm Indicator Light (RAIL) equipped.
- D. Spot type smoke detectors mounted within 12 feet of a walking surface shall have their built-in locking device activated. Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed. Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.
- E. Ceiling-Mounted Smoke Detectors: Not less than 4 inches (100 mm) from a side wall to the near edge. For exposed solid-joint construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet (9 m) apart in any direction.
- F. Wall-Mounted Smoke Detectors: At least 4 inches (100 mm), but not more than 12 inches (300 mm), below the ceiling.
- G. Smoke Detectors near Air Registers: Install no closer than 36 inches (1520 mm).
- H. All air duct/plenum detectors must have a RAIL located in the nearest corridor or public area and identified by an engraved label affixed to the wall or ceiling. These detectors shall be installed in a manner that provides suitable access for required periodic cleaning and calibration.
- I. Duct detector sampling tubes shall extend the full width of the duct. Those over 36 inches long must be provided with rear support. The preferred method for doing this is to have the tube go through the far side of the duct, with the point of penetration tightly sealed to prevent air leakage around the tube. This facilitates smoke testing and tube cleaning. Duct smoke detector mounting position and air sampling tube orientation, are critical for proper operation. The Manufacturer's detailed installation instructions must be followed. The Contractor shall mark the direction of air flow on the duct at each duct detector location. Each duct detector installation shall have a hinged or latched access panel, 12"x12" minimum, for sampling tube inspection and cleaning. Coordinate with Mechanical Contractor.
- J. Smoke detector guards, where indicated on the Drawings shall be Listed for use with the specific model of smoke detector being protected. All smoke detector guards are to have a separate base which must be very securely anchored to wall or ceiling. The cover must be readily removable by the Owner for periodic detector cleaning and servicing but, to prevent unauthorized entry, must be secured to the base by a lock or tamper resistant screws approved by the Engineer. Metal guards must be 16 gauge or heavier steel.

3.3 SPRINKLER SYSTEM MONITORING

- A. The following sprinkler system alarm and supervisory functions shall be provided as a part of the fire alarm system:
 - 1. Waterflow alarm, by sprinkler zone (not to exceed one floor).
 - 2. Supervision of each control valve.
 - 3. Supervision of air pressure, if used (both high and low).
- B. Sprinkler supervisory monitoring of flow switches, tamper switches, and similar functions shall be accomplished with a separate system address for each activity monitored.

3.4 FIRE ALARM CONTROL PANEL PROGRAMMING

- A. Programming of the FACP and connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.
- B. The complete configuration data (site-specific programming) for the system must be permanently stored on a computer disk and archived by the manufacturer or authorized distributor. A disk copy of this data must be submitted to the Engineer for transmission to the Owner when the system is commissioned.
- C. The Manufacturer or authorized distributor must maintain software version (VER) records on the system installed. The system software shall be upgraded free of charge if a new VER is released for any reason during the warranty period. For any new VER to correct problems, free upgrade shall apply during the entire life of the system.
- D. The Fire Alarm System shall have multiple access levels which permit the Owner's authorized personnel to make temporary changes in the system alarm response matrix without actually changing the system programming. This must include the ability to override selected alarm inputs or system responses to alarms without affecting the remaining portions of the system.
 - 1. The fire alarm system shall have a self-contained modem with a minimum speed of 9,600 baud for external communications purposes. All system functions and programming features must be available through the modem port. The modem port shall be password protected with multiple access levels as described above.
- E. In addition to the system tests and certification described elsewhere, the Manufacturer or authorized distributor must 100% test all site-specific software functions for the system and provide a written test report or detailed check list. This documentation must include a system operation matrix showing the actual FACP response for each initiating device input.

3.5 SYSTEM LABELING

- A. Detectors and initiating devices: Identification of individual detectors is required by a unique alphanumeric label. These device labels, which must also be shown on the

shop drawings, shall be permanently affixed to the detector base. Device labels may not be affixed to the device head. Identification labels must be printed labels with black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.

1. Loop 1 shall be assigned to the lowest floor devices and loop number shall increase with floor number. Device number starts in the same location on each floor and increase accordingly as circuit location increases.
- B. Notification Appliances: Notification appliances shall be clearly labeled with NAC panel and circuit number. Add "EOL" designation to label where an end-of-line resistor is located in the junction box behind the notification appliance.
- C. FACP and System Equipment: Provide an engraved label in FACP identifying its 120 VAC power source. This label shall include panelboard location, identification, and circuit number. Labels shall also be provided for auxiliary panels, NAC panels, and power extenders.
- D. Zone Map: Provide framed zone map at FACP and at all remote annunciators.
- E. Provide framed basic operating instructions at FACP.
- F. Floor Plans with Device Numbers: A copy of the floor plans shall be provided in the control panel. A separate sheet shall be provided for each floor. Plans shall be reduced in size from engineering plans in order to fit on 11x17 sheets. All device addresses shall be clearly labeled on plans. Minimum printed text size shall be 0.75/10". Indicate location of all cabinets, modules, and end of line resistors. Plans shall be laminated and bound in book form. Provide legend for symbols. Provide holder for plan book in panel or in a locked box adjacent to panel keyed to match panel. Provide label for box and book.

3.6 PHYSICAL PROTECTION

- A. Manual pull-stations: Provide indoor protective shield. Lifting the clear plastic cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
- B. Visual alarm appliances: Provide protective wire guards, manufactured specifically for strobes, for all strobes/visual alarm appliances located in gymnasiums, multi-purpose rooms, weight rooms, and other areas where appliances are subject to physical damage. Visual alarm appliances located in kitchens shall be direct-spray waterproof.

3.7 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer. Replace damaged units.

PART 4 - SYSTEM TESTING & CERTIFICATION**4.1 TESTING**

- A. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
1. Minimum System Tests: Minimum test shall be a 100% operation test including, but not limited to the following-
 - a. Verify the absence of unwanted voltages between circuit conductors and ground.
 - b. Test all conductors for short circuits using an insulation-testing device.
 - c. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
 - d. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
 - e. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - f. Test all initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - g. All circuits shall be tested for supervision. Signal Line Circuits shall be tested for "Class A".
 - h. All sprinkler devices shall be tested for alarm, supervisory and trouble situations.
 - i. All control circuits (AHU shutdown, door holders, dampers) shall be tested for proper operation on an alarm condition and for wire supervision.
 - j. Check zone map for proper location of all devices. Verify that devices and wire are properly labeled.
 - k. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all audible notification signals for routing, clarity, quality, freedom from noise and distortion, and proper volume level.
 - l. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

- B. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.
- C. Engineer's Test: After the pretest has been completed and the system is clear of trouble all test documentation including a printout of all custom labels and a NFPA 72 "Record of Completion" form shall be submitted to Engineer for approval. At that time Engineer may, at his discretion, perform a 100% functional test of the fire alarm system. The Contractor and the Manufacturer's authorized representative that installed the system must be present. Should the results of this test not be satisfactory, then corrections will be made and a re-test will be required at the Contractor's expense.
- D. Authority Having Jurisdiction Inspection/Test: Only after Engineer has approved the system the design professional will schedule the inspection. The Contractor and the Manufacturer's authorized representative must be present for test. Provide a minimum of 10 days' notice in writing to the Engineer for the Authority Having Jurisdiction Inspection/Test.
- E. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.
- F. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- G. Closeout: After successful completion of inspections and tests, the warranty period begins. In the event of malfunctions or excessive nuisance alarms, the Contractor must take prompt corrective action. The Owner may require a repeat of the Contractor's 100% system test, or other inspections. Continued improper performance during the warranty period shall be cause to require the Contractor to remove and replace the system.

4.2 TEST EQUIPMENT

- A. Contractor shall provide two-way radios, ladders, smoke candles or test magnet, and any other materials needed to test the system.

4.3 OWNER'S TRAINING/DEMONSTRATION

- A. The Manufacturer's authorized representative shall provide training for the Owner's designated employees in proper operation of the system and in all required periodic maintenance. Scheduling of training must be arranged to meet the Owner's schedule. The instruction shall include a minimum of three (3) copies of a written, bound training summary, for future reference. Basic operating instructions shall be framed and mounted at the FACP.
- B. Training shall cover the following topics as a minimum:

1. Preventative maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
2. Overall system concepts, capabilities, and functions. The Owner shall be able to add or delete devices to the system and to take any device out of service and return any device to service without need for Manufacturer's approval.
3. Explanation of all control functions, including training to program and operate the system software.
4. Methods and means of troubleshooting and replacement of all field wiring and devices.
5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided on CD and shall be left with the Owner at the completion of training for the Owner's use in the future.

4.4 DOCUMENTATION

- A. The Contractor shall provide the Engineer with three (3) copies of the following:
 1. As-built floor plans with device numbers, wiring and conduit layout diagrams, including wire color code and/or label numbers, and showing all interconnections in the system. Provide on paper and in AutoCAD 2000 or later electronic media format.
 2. Electronic circuit diagrams of all control panels, modules, annunciators, communications panels, etc.
 3. Technical literature on all major parts of the system, including control panels, batteries, detectors, manual stations, alarm indicating appliances, power supplies, and remote alarm transmission means.
- B. The Contractor shall provide the Owner with three (3) interconnection cables to connect the fire alarm system to a PC.

4.5 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 268311

SECTION 311000 - SITE CLEARING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Removing surface debris.
 - 2. Removing designated paving, and curbs.
 - 3. Removing designated trees, shrubs, and other plant life.
 - 4. Excavating topsoil.
 - 5. Clearing and Grubbing

1.2 Related Sections:

- A. The following sections have work that is directly related to this Section. This does not relieve the Contractor of their responsibility to properly coordinate all work.
- B. 1. Section 013000 Administrative Requirements
- C. 2. Section 312500 Erosion and Sedimentation Controls

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Refer to Section 012000 Price and Payment Procedures

1.4 SUBMITTALS

- A. Not Used

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with approved Permits and all local, state, and federal requirements.

PART 2 - PRODUCTS**2.1 Not Used****PART 3 - EXECUTION****3.1 EXAMINATION**

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify existing plant life designated to remain is tagged or identified.
- C. Identify waste area and salvage area for placing removed materials.

3.2 PREPARATION

- A. Call Local Utility Line Information service in advance of performing work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

- A. Locate, identify, and protect utilities indicated to remain, from damage.

- B. Protect trees, plant growth, and features not designated for removal.
- C. Protect bench marks, survey control points, and existing structures from damage or displacement.

3.4 EROSION CONTROL MEASURES

- A. Clear areas required to install erosion control devices, which shall be in place and operational prior to other land disturbing activities. Install erosion control devices in accordance with approved permit and Section 312500 Erosion and Sedimentation Controls.

3.5 CLEARING AND GRUBBING

- A. Clear areas required for access to site and execution of Work.
- B. For open cut installation, clear and grub total width of permanent easement. Clear within temporary construction easement only as necessary for construction. Do not grub within the temporary construction easement. For horizontal directional drill or bore and jack installation, do not clear and grub beyond installation pits, unless required to complete construction.
- C. Clearing shall consist of cutting and removal of vegetation to the existing ground surface and removal of debris.
- D. Grubbing shall consist of the removal of roots over 3 inches in diameter. Matted roots, stumps, and other vegetable mater to 12-inches below existing grade.
- E. Do not precede grading operations by grubbing operation by more than seven days.
- F. Fill holes and depressions being cleared and grubbed to a uniform contour to match existing grade. Provide positive drainage.
- G. Remove and properly dispose of cleared and grubbed material from the site.
- H. Burning shall not be permitted at the site.

3.6 REMOVAL

- A. Remove debris, rock, and extracted plant life from site.
- B. Remove paving, curbs, and other items indicated for removal.
- C. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.
- D. Do not burn or bury materials on site. Leave site in clean condition.

3.7 TOPSOIL EXCAVATION

- A. Excavate topsoil from entire site, without mixing with foreign materials for use in finish grading.
- B. Excavate wet topsoil and allow to adequately dry before using.
- C. Stockpile in area(s) designated on site and protect from erosion. Stockpile material in accordance with approved Erosion Control Plans until disposal or re-use.
- D. Remove excess topsoil not intended for reuse, from site.

3.8 BORROW AND DISPOSAL AREAS

- A. Obtain and pay for erosion control permit for borrow and disposal areas as required by Contractor.
- B. Install and maintain erosion control devices in accordance with Contractor's approved plan.

END OF SECTION 311000

SECTION 312213 - EXCAVATING, GRADING, TRENCHING, & BACKFILLING

1.1 General:

The contractor shall furnish all labor, equipment, supplies and materials, and perform all operation in connection with the excavations, grading and backfilling, including borrow for drainage structures, curb and gutter, sidewalks, driveways, pavements, slopes, storm drains, water and sanitary sewer lines, including all hauling, wetting, rolling and other operations pertaining thereto within the clearing limits, complete, in strict accordance with this section of the specifications and the applicable drawings, and subject to the terms and conditions of the contract.

1.2 Existing Conditions

- A. Every reasonable effort has been made to provide accurate information on existing site conditions. The Contractor should become familiar with the site and satisfy himself as to the scope of the work involved and the materials to be encountered. Any significant change in conditions should be immediately brought to the attention of the Owner's representative.

1.3 References

- A. ASTM C33 - Standard specification for concrete aggregates
- B. ANSI/ASTM C136 - Sieve analysis of fine and coarse aggregates.
- C. ANSI/ASTM D698 - Tests for moisture-density relations of soils and soil-aggregate mixture using 5.5 lb (2.49 kg) rammer and 12 inch (305 mm) drop.
- D. ANSI/ASTM D1556 - Density of soil in place by sand-cone method.
- E. ASTM D2487 - Classification of soils for engineering purposes.

PART 2 PRODUCTS

2.1 Soils

- A. General: Use soils free of organic matter, refuse, rocks and lumps greater than 4 inches in diameter and other deleterious matter.
 - 1. Backfilling Materials: Suitable material, when used as backfill in paved areas, shall be capable of being compacted as specified in paragraph "Compaction and Testing" of this section of these specifications.
 - a. Type 1 Material: Excavated material from the trench or materials from other sources which are free from large clods, roots or stones larger than 1 inch may be used as initial backfill in trenches (see Trench Details)

- b. Type 2 Material: Excavated material from the trench or materials from other sources which are free from large clods, roots or stones larger than 8 inches may be used as final backfill in trenches (see Trench Details)
- B. Classification: For the purpose of this specification, soils to be used as fill material are grouped into five classes according to soil properties and characteristics.

Class I - Angular, 6 to 40-mm (1/4 to 1-1/2 in.), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed tone, crushed gravel, and crushed shells.

Class II - Coarse sands and gravels with maximum practical size of 44 mm (1-1/2 in.), including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class.

Class III - Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil Types GM, GC, SM, and SC are included in this class.

Class IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH, and CL are included in this class. These materials are not recommended for bedding, haunching, or initial backfill.

Class V - This class includes the organic soil, OL, OH, PT as well as soils containing frozen earth, debris, rocks, larger than 40 mm (1-1/2 in.) in diameter, and other foreign materials. These materials are not recommended for bedding haunching or initial backfill.
- C. Topsoil: Natural, friable soil free of subsoil, stumps, rocks larger than 2 inches in diameter, weeds and other material detrimental to plant growth.
- D. Granular Fill: Granular fill under floor slabs shall be Class I material.
- E. Structural Fill: Fill material placed inside the line of the building foundation or slab shall be Class I or II.
- F. Fill Beneath Pavement: Fill material used beneath pavement and for road shoulders shall be Class II or III.
- G. General Fill: General fill material not otherwise specified shall be Class II or III.
- H. Trench Backfill: Material used for bedding, haunching and initial backfill shall be as specified hereinafter.

- 2.2 Crushed Stone:** Crushed stone shall be size no. 57, washed stone. If fines are insufficient, stone screenings shall be added to extent required to stabilize it in the trench.
- 2.3 Concrete:** Concrete placed for cradles, thrust blocks, or encasement shall be Class B concrete as specified in Section 03300 Cast-in-Place Concrete.

PART 3 EXECUTION

3.1 General

- A. Familiarization: Prior to commencement of the earthwork, become thoroughly familiar with the site, the site conditions, and all portions of the work specified in this Section.
- B. Approvals: Backfilling and grading operations near foundations, walls, pipes and other portions of the work to be covered shall not commence until the Owner's Representative has completed all required inspections, tests and approvals. Work covered prior to inspection shall be uncovered for inspection purposes and backfilled.

3.2 Surface Preparation

- A. Clearing: Areas designated for clearing and required for construction operations shall be cleared of trees, brush, structures and other materials. Trees which are to remain shall be protected during clearing operations and subsequent work.
- B. Grubbing: Roots, stumps and other materials shall be grubbed from the cleared areas to a depth of at least 18 inches. Tree stumps shall be grubbed in their entirety, including tap roots where applicable.
- C. Topsoil: Strip existing topsoil to a depth of 4 inches from areas to be excavated or graded. Stockpile the topsoil in a suitable area for use during final grading operations. Protect the topsoil from excessive erosion.
- D. Unsuitable Material: Remove sod, muck or other unsuitable material to firm subsoil in areas designated for filling or grading operations.
- E. Disposal: Trees, stumps, roots, rubbish, unsuitable soil or other material resulting from surface preparation shall be removed from the site by the Contractor and disposed of.

3.3 Excess Water Control

- A. General: Grade and maintain all areas of the site to preclude surface runoff into excavations and prevent ponding of water.
- B. Dewatering: Excavations should be kept free of surface water and/or groundwater. Provide and maintain at all times the necessary means and devices

to prevent water from entering the excavations and for removing all water entering the excavations, at no additional cost to the owner.
- C. Softened Subgrade: Remove all soil softened or eroded by the presence of water and replace with suitable backfill material.

- 3.4 Excavation:** Excavation shall be accomplished in accordance with the grades and lines as established by the Engineer and as required by the work to be performed. Excavation shall include the removal and replacement of all asphalt, concrete, curb, rock, earth, fences, trees (as directed by the Engineer), shrubs, and other materials as applicable. The contractor will exercise care to prevent undercutting lower than the required subgrades. All materials from excavation, considered as suitable by the Engineer, shall be used as fill wherever required, and the Contractor shall arrange his work so that this usage of excavated materials will be possible. Unsuitable and surplus materials from excavation, if any, shall be disposed of by the Contractor at this expense. All areas of the site shall be graded and maintained at all times to prevent surface runoff from draining into the excavations, and to prevent ponding of water therein.

Excavated materials not required for topsoil, fill or backfill shall be removed from the site of the work by the Contractor, but none shall be deposited on private property without written consent of the property owner.

- A. Unsuitable Materials: Unsuitable materials encountered in an excavation shall be removed as directed by the Owner's representative, backfilled with suitable material and compacted. Unsuitable materials include organic soils, muck, soft and compressible silts and clays and running sands.
- B. Undercutting: Undercutting, unless authorized by the Engineer, shall be replaced and compacted, as specified in paragraph 3.06, at the Contractor's expense. If the material, after excavation to subgrade, is found to be soft, spongy or unfit for use as subgrade, such unsuitable material shall be removed to a depth as directed by the Engineer and the subgrade shall be brought to proper elevation by filling with suitable material from excavation or from an approved borrow site.
- C. Borrow: The Contractor will supply all borrow necessary and will provide all labor and equipment necessary to dig and haul such borrow. The placing of borrow shall be as provided for in the paragraph 3.06.

3.5 PREPARATION OF SUBGRADE

- A. General: Upon completion of site preparation and excavation, scarify to a depth of 12 inches and compact as specified. For areas to receive fill, the compacted subgrade shall be scarified to a depth of four inches prior to placing the fill.

3.6 FILL AND COMPACTION

- A. When and where existing plans and grades require the use of fill to reach the required elevation, the Contractor shall deposit suitable material from previously excavated areas. Such material shall be free from debris, roots, trash, stones, or other harmful substances, and shall be spread in successive layers of loose material not more than 8 inches in depth. Each layer shall be spread uniformly by motor grader or other approved device and rolled with an approved tamping or three-wheeled power roller until thoroughly compacted to 90 percent of maximum density obtained at optimum moisture content, as determined by the A.A.S.H.T.O. Standard Method T-180.

When any portion of the fill is constructed on an old road bed, the existing surfaces shall be scarified and manipulated as directed by the Engineer in order that, when compacted, it shall have a uniform density, as specified above. Fills shall be shaped and maintained at all times during their construction to prevent an accumulation of standing water in the event of rain.

- B. Moisture Conditioning: Moisten or aerate the subgrade and fill material as required to obtain proper compaction.
- C. Structural Fill: Compact the subgrade and fill to a minimum of 98 percent ASTM D698 (Standard Proctor) maximum density at optimum moisture content.
- D. Granular Fill: Place granular fill on compacted, unscarified fill or subgrade and compact to a minimum 100 percent ASTM D698, maximum density at optimum moisture content.
- E. Pavement Areas: Compact the subgrade and fill material beneath paved areas and shoulders to a minimum 100 percent ASTM D698 maximum density at optimum moisture content.
- F. Landscaped Areas: Compact the subgrade and fill to a minimum 98 percent ASTM D698 maximum density at optimum moisture content. Compact topsoil to 85 percent ASTM D698 maximum density at optimum moisture content.

3.7 Finish Grading

- A. General: Perform finish grading to the lines and grades shown on the drawings. Finished grades should be smooth and uniform and provide positive drainage.
- B. Tolerances:
 - 1. Rough Grade Plus or minus 0.1 foot
 - 2. Finish Grade Plus or minus 0.1 foot
- C. Topsoil: The top 4 inches of soil in landscaped areas shall be topsoil.
- D. Protection: Protect areas which have been graded from equipment traffic.

3.8 Trenching, Backfilling and Compaction for Utility Systems

- A. General: Refer to specific utility sections in these specifications for installation requirements. Trench, backfill and compact as specified except as modified herein.
- B. Trenching: Trench widths at and below the top of the pipe shall be the minimum necessary for proper installation. Trench banks above the top of the pipe shall be as vertical as practicable. Overdepth excavation shall be backfilled with Class I material and compacted. The Contractor shall provide, at his expense and as directed by the Owner's representative, special bedding material or concrete encasement as may be necessary due to over-width excavation.
- C. Depth: Trench to the lines and grades shown on the drawings. Where elevations are not shown, trench to a depth sufficient to provide at least 36 inches of cover above the top of pipe, unless otherwise specified. Grade trenches to provide a constant slope free of sags and high spots.
- D. Dewatering: Keep trenches free of water. Include cost of dewatering in unit price bid for pipe. No additional payment for this item is permitted.
- E. Trench Bracing: Properly brace, sheet and support trench walls as soil conditions indicate and in strict conformance with all pertinent laws and OSHA regulations. Provide adequate bracing and shoring to protect adjacent improvements. Contractor shall provide certification for all premanufactured trench bracing devices prior to any excavation activities.
- F. Bedding, Haunching and Initial Backfill: Tamp to provide firm, even bedding. Excavate bedding material to match the shape of the bottom of the pipe and bell, as detailed in the drawings. Place haunching material so as to provide full bearing around the bottom of the pipe. Place bedding haunching and initial backfill as

specified below.

G. Pipe Bedding:

1. P.V.C. Gravity Main - Provide six (6) inches of Class I bedding material compacted to 98 percent ASTM D698 density. Haunching material shall be Class I material compacted to 98 percent ASTM D698 density. Haunching of pipe from invert to springline shall be by hand placement to ensure material is worked under Haunch. Initial backfill shall be Class I to top of pipe (washed 157 stone preferred).
2. D.I.P. and C900/905 PVC Gravity Main - Provide six (6) inches of Class I bedding material compacted to 98 percent ASTM D698 density. Haunching material shall be Class I material compacted to 98 percent ASTM D698 density. Haunching of pipe from invert to springline shall be by hand placement to ensure material is worked under Haunch. Initial backfill shall be Class I to springline of pipe Class I, II or III material to top of pipe.
3. Pressure Main P.V.C. or D.I.P. - Provide six (6) inches of Class I or II bedding material compacted to 98 percent ASTM D698 density. Haunching material shall be Class I or II material compacted to 98 percent ASTM D698 density. Haunching of pipe from invert to springline shall be by hand placement to ensure material is worked under Haunch. Initial backfill shall be Class I or Class II to top of pipe Class I, II or III material from top of pipe to 6-inches above pipe.
4. Service Pipe (Schedule 40) - Provide six (6) inches of Class I or II bedding material compacted to 98 percent ASTM D698 density. Haunching material shall be Class I or II material compacted to 98 percent ASTM D698 density. Haunching of pipe from invert to springline shall be by hand placement to ensure material is worked under Haunch. Initial backfill shall be Class I or II to top of pipe.

H. Backfill: Backfill the remainder of the trench in accordance with paragraphs 2.01 and 3.06 of this section. Backfill from embedment zone to surface grade may be by hand or mechanical placement. Trench backfill shall be compacted in 8-inch lifts.

I. Foundation: Foundation shall be required in wet, yielding and mucky locations. Foundation shall be constructed by removal of wet, yielding or mucky material and its replacement with sufficient Class I material to correct the instability. In areas where foundation is required bedding shall be class I only.

J. Backfilling in Traffic Areas (Highways, paved streets, paved parking lots, alleys, driveways, highway and street shoulders)

1. Initial Backfilling of Pipe (Ordinary Bedding for DIP Pipe)

- a. After preparing the trench for ordinary bedding as described under paragraph 3.08G of this section, this portion of the pipe trench shall be backfilled with suitable materials (Type 1) under and around the pipe, carefully deposited in uniform layers on both sides of pipe and compacted by hand or pneumatic tampers until backfill reaches one (1) foot above top of pipe. The depth of backfill layers shall be six (6) inches maximum. Each layer of material shall be compacted to a dry density 95 percent of the maximum determined by the Standard Proctor Compaction Test.
 - b. When crushed stone or concrete encasement is used, the initial backfill of suitable materials will not be required.
 - c. The tampers shall be of proper sized to operate between trench wall and pipe without damaging the pipe.
2. Initial Backfilling of Pipe (Crusted Stone Encasement for PVC pipe, DIP in unstable or wet conditions, or crushed stone encasement)
 - a. This portion of the pipe trench shall be backfilled with crushed stone to provide crusted stone encasement.
 - b. When concrete cradle is used, the initial backfill will start at the top of the concrete and then continue as specified above.
 - c. When concrete encasement is used, the initial backfill of crushed stone will not be required.
3. Backfilling Trench to Subgrade After Initial Backfilling (Suitable Materials)
 - a. After initial backfilling has been compacted as specified above, backfill the remainder of the trench in compacted layers not to exceed twelve (12) inches using a mechanical tamper up to the bottom elevation of the pavement structure with suitable materials (Type 2) to be a dry density 95 percent of the maximum determined by the Modified Proctor Compaction Test.

3.9 FIELD QUALITY CONTROL

- A. Field inspection, sampling and testing will be performed per owner's instructions.
- B. An independent soils engineering and testing laboratory shall perform sufficient tests and inspection procedures, to the satisfaction of the Engineer, both in the field and lab to ensure that the provisions of this specification are met. The testing shall be paid by the Contractor. The testing lab shall be approved by the Engineer.

After testing is completed and reports are provided, all subgrades below the paving will be examined by the Engineer before any paving is authorized.

The responsibility of the soils engineering and testing laboratory is to the Engineer, to whom that firm must promptly, faithfully and accurately report the results of its tests and inspections. The firm must, in addition, work in coordination with the Contractor, making all tests required. The reports must state whether or not the reported results comply with contract requirements. The testing and control firm shall promptly type and deliver all its reports to the Engineer with a copy to the Contractor.

PART 4 PAYMENT

4.01 PAYMENT

No separate payment will be made for Excavating, Grading, Trenching and Backfilling. All costs incurred by the contractor for this work should be included in the unit price or lump sum price for the item of work to which it pertains.

END OF SECTION 312213

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SECTION 31 23 19 - DEWATERING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Dewatering system.
 - 2. Surface water control system.
 - 3. Monitoring wells.
 - 4. System operation and maintenance.
 - 5. Water disposal.
- B. Related Sections:
 - 1. Section 31 23 16.13 - Trenching
 - 2. Section 31 25 00 - Erosion and Sedimentation Controls

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Refer to Section 01 20 00 Price and Payment Procedures

1.3 REFERENCES

- A. ASTM International:
 - 1. ASTM C33 - Standard Specification for Concrete Aggregates.

1.4 DEFINITIONS

- A. Dewatering includes the following:
 - 1. Lowering of ground water table and intercepting horizontal water seepage to prevent ground water from entering excavations and trenches.
 - 2. Reducing piezometric pressure within strata to prevent failure or heaving of excavations and trenches.
 - 3. Disposing of removed water.
- B. Surface Water Control: Removal of surface water within open excavations.

1.5 SYSTEM DESCRIPTION

- A. Provide dewatering and surface water control systems to permit Work to be completed on dry and stable subgrade.
- B. Provide monitoring wells and monitoring equipment to obtain meaningful observations of conditions affecting excavation.

1.6 PERFORMANCE REQUIREMENTS

- A. Provide dewatering systems to:
 - 1. Lower water table within areas of excavation to minimum 1 foot below bottom of excavation to permit Work to be completed on dry and stable subgrade. Maintain water table low enough to provide a stable trench bottom in all cases.
 - 2. Relieve hydrostatic pressures in confined water bearing strata below excavation to eliminate risk of uplift or other instability of excavation.
 - 3. Prevent damage to adjacent properties, buildings, structures, utilities, and facilities from construction operations.
 - 4. Prevent loss of fines, quick condition, or softening of foundation subgrade.
 - 5. Maintain stability of sides and bottoms of excavations and trenches.

- B. Provide surface water control systems to:
 - 1. Collect and remove surface water and seepage entering excavation.

1.7 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Shop Drawings: [Signed and sealed by professional engineer.]
 - 1. Indicate dewatering system layout, well depths, well screen lengths, dewatering pump locations, pipe sizes and capacities, grades, filter sand gradations, surface water control devices, valves, and water disposal method and location.
 - 2. Indicate primary and standby power system location and capacity.
 - 3. Indicate layout and depth of monitoring wells, piezometers and flow measuring devices for system performance measurement.
 - 4. Include detailed description of dewatering and monitoring system installation procedures and maintenance of equipment.
 - 5. Include description of emergency procedures to follow when problems arise.

1.8 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations and depths of capped wells and piping abandoned in place.

1.9 QUALITY ASSURANCE

- A. Comply with authorities having jurisdiction for the following:
 - 1. Drilling and abandoning of wells used for dewatering systems.
 - 2. Water discharge and disposal from pumping operations.
- B. Perform Work in accordance with all applicable local, state, and federal requirements.

1.10 PRE-INSTALLATION MEETINGS

- A. Section 013000 - Administrative Requirements: Pre-installation meeting.

1.11 SEQUENCING

- A. Section 011000 - Summary: Requirements for sequencing.
- B. Sequence work to obtain required permits before start of dewatering operations.
- C. Sequence work to install and test dewatering and surface water control systems minimum 7 days before starting excavation and trenching.

1.12 COORDINATION

- A. Section 013000 - Administrative Requirements: Requirements for coordination.
- B. Coordinate work to permit the following construction operations to be completed on dry stable substrate.
 - 1. Trenching for utilities specified in Section 312316.13.

PART 2 - PRODUCTS**2.1 DEWATERING EQUIPMENT**

- A. Select dewatering equipment to meet specified performance requirements.
- B. Furnish materials in accordance with all applicable local, state, and federal requirements.

2.2 MONITORING EQUIPMENT

- A. Provide Piezometers or other means of measuring ground water elevations as required to complete scope of work.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Conduct additional borings and investigations to supplement subsurface investigations as required to complete dewatering system design.

3.2 PREPARATION

- A. Protect existing adjacent buildings, structures, and improvements from damage caused by dewatering operations.

3.3 MONITORING WELLS

- A. Install monitoring wells as required.
- B. Test each monitoring well point to verify installation is performing properly.
- C. Install piezometers, calibrate, and test for proper operation.
- D. Protect monitoring well standpipes from damage by construction operations.
- E. Maintain accessibility to monitoring wells continuously during construction operations.
- F. Maintain monitoring wells until groundwater is allowed to return to normal level.

3.4 DEWATERING SYSTEM

- A. Install dewatering system as required to complete the scope of work.
- B. Locate system components to allow continuous dewatering operations without interfering with installation of permanent Work and existing public rights-of-way, sidewalks, and adjacent buildings, structures, and improvements.

3.5 SURFACE WATER CONTROL SYSTEM

- A. Provide ditches, berms, and other devices to divert and drain surface water from excavation area as specified in Section 312500 Erosion and Sedimentation Controls.
- B. Control and remove unanticipated water seepage into excavation.

3.6 SYSTEM OPERATION AND MAINTENANCE

- A. Operate dewatering system continuously until backfilling is complete.
- B. Provide 24-hour supervision of dewatering system by personnel skilled in operation, maintenance, and replacement of system components.
- C. Conduct daily observation of dewatering system and monitoring system. Make required repairs and perform scheduled maintenance.
- D. Fill fuel tanks before tanks reach 25 percent capacity.
- E. Start emergency generators at least twice each week to check operating condition.
- F. When dewatering system cannot control water within excavation:
 - 1. Supplement or modify dewatering system and provide other remedial measures to control water within excavation.
- G. Modify dewatering and surface water control systems when operation causes or threatens to cause damage to new construction, existing site improvements, adjacent property, or adjacent water wells.
- H. Correct unanticipated pressure conditions affecting dewatering system performance.

- I. Do not discontinue dewatering operations without Engineer's approval.

3.7 WATER DISPOSAL

- A. Discharge water into natural water course in accordance with Section 312500 Erosion and Sedimentation Controls.

3.8 SYSTEM REMOVAL

- A. Remove dewatering and surface water control systems after dewatering operations are discontinued. Removal shall be in accordance with all applicable local, state, and federal requirements.

3.9 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements and 017000 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

END OF SECTION 312319

SECTION 312500 - EROSION AND SEDIMENTATION CONTROLS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Temporary Construction Entrance
 - 2. Temporary Seeding
 - 3. Permanent Seeding
 - 4. Temporary Silt Fence
- B. Related Sections:
 - 1. Section 311000 - Site Clearing.
 - 2. Section 312213 - Excavating, Grading, Trenching, and Backfilling
 - 3. Section 329219 - Seeding and Soil Supplements.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Refer to Section 012000 Price and Payment Procedures

1.3 REFERENCES

- A. NC Department of Transportation – Standard Specifications for Roads and Structures (NCDOT)
- B. NC Department of Environmental Quality (NCDEQ) – Erosion and Sediment Control Planning and Design Manual (ESM)

1.4 SUBMITTALS

- A. Section 01 33 00 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Product Data:
 - 1. Temporary Construction Entrance
 - 2. Temporary Seeding
 - 3. Permanent Seeding
 - 4. Temporary Silt Fence

1.5 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.

1.6 QUALITY ASSURANCE

- A. Perform work in accordance with approved Erosion Control Permit.

1.7 PRE-INSTALLATION MEETINGS

- A. Section 013000 - Administrative Requirements: Pre-installation meeting.

PART 2 - PRODUCTS**2.1 TEMPORARY CONSTRUCTION ENTRANCE**

- A. Provide materials in accordance with NCDEQ ESM Section 6.06 and as indicated on drawings.

2.2 TEMPORARY SEEDING

- A. Provide materials in accordance with NCDEQ ESM Section 6.10, as indicated on drawings, and Section 329219 Seeding

2.3 PERMANENT SEEDING

- A. Provide materials in accordance with NCDEQ ESM Section 6.11, as indicated on drawings, and Section 329219 Seeding.

2.4 TEMPORARY SILT FENCE

- A. Provide materials in accordance with NCDEQ ESM Section 6.62 and as indicated on drawings.

2.5 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Testing, inspection and analysis requirements.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 01 30 00 - Administrative Requirements: Verification of existing conditions before starting work.

3.2 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements and 017000 - Execution and Closeout Requirements
- B. Inspect and maintain all erosion control devices in accordance with the approved erosion control permit and as indicated on the drawings.

3.3 SEQUENCE OF CONSTRUCTION

- A. Sequence the installation of erosion control devices in accordance with the approved erosion control permit and as indicated on drawings.

3.4 TEMPORARY CONSTRUCTION ENTRANCE

- A. Construct and maintain in accordance with NCDEQ ESM Section 6.06 and as indicated on drawings.

3.5 TEMPORARY SEEDING

- A. Construct and maintain in accordance with NCDEQ ESM Section 6.10, as indicated on drawings, and Section 329219 Seeding.

3.6 PERMANENT SEEDING

- A. Construct and maintain in accordance with NCDEQ ESM Section 6.11, as indicated on drawings, and Section 329219 Seeding.

3.7 TEMPORARY SILT FENCE

- A. Construct and maintain in accordance with NCDEQ ESM Section 6.62 and as indicated on drawings.

END OF SECTION 31 25 00

SECTION 31 31 16**TERMITE CONTROL****PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Soil treatment.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Soil Treatment Application Report: Include the following:
 - 1. Date and time of application.
 - 2. Moisture content of soil before application.
 - 3. Termiticide brand name and manufacturer.
 - 4. Quantity of undiluted termiticide used.
 - 5. Dilutions, methods, volumes used, and rates of application.
 - 6. Areas of application.
 - 7. Water source for application.
- C. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1.6 WARRANTY

- A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites, including Formosan termites (*Coptotermes formosanus*). If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 SOIL TREATMENT**

- A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BASF Corporation.
 - b. Bayer Environmental Science.
 - c. Ensysstex, Inc.
 - d. Syngenta.
 2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated.

3.2 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.
1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
 3. Crawlspace: Soil under and adjacent to foundations. Treat adjacent areas, including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
 4. Masonry: Treat voids.
 5. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.
- B. Post warning signs in areas of application.
- C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

END OF SECTION 31 31 16

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SECTION 321216 - ASPHALT PAVING**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Asphalt materials.
2. Aggregate materials.
3. Aggregate subbase.
4. Asphalt paving base course, binder course, and wearing course.
5. Pavement Markings and Signage

B. Related Requirements:

The following sections have work that is directly related to this Section. This does not relieve the Contractor of their responsibility to properly coordinate all work.

1. Section 312213 - Excavating, Grading, Trenching, & Backfill: Preparation of site for paving and base.
2. Section 321623: Concrete Sidewalks and Curbs.

1.2 PRICE AND PAYMENT PROCEDURES**A. Refer to Section 012000 - Price and Payment Procedures****1.3 REFERENCE STANDARDS****A. American Association of State Highway and Transportation Officials:**

1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.

B. ASTM International:

1. ASTM C136/C136M – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D1188 - Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
3. ASTM D1556 – Standard Test Methods for Density and Unit Weight of Soil in Place by Sand Cone Method
4. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (Modified Proctor)

5. ASTM D2726 - Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures.
 6. ASTM D2950 - Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods.
 7. ASTM D3549 - Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens.
 8. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil Aggregates by Nuclear Methods (Shallow Depth)
- C. North Carolina Department of Transportation (NCDOT)
1. 2012 NCDOT Standard Specification for Roads and Structures (NCDOT RS)
- D. US Federal Highway Administration (FHWA)
1. 2009 Manual on Uniform Traffic Control Devices (MUTCD)

1.4 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
1. Submit product information for asphalt and aggregate materials.
 2. Submit mix design with laboratory test results supporting design.
 3. Submit product information for pavement markings and traffic signs
- C. Test Reports
1. Submit results of quality control tests for Density, Thickness, Straightedge

1.5 QUALITY ASSURANCE

- A. Mixing Plant: Certified by NCDOT
- B. Obtain materials from same source throughout unless approved by Engineer
- C. Perform Work in accordance with NCDOT standards and specifications. Paragraphs in NCDOT RS entitled "Method of Measurement" and "Basis of Payment" shall not apply.

1.6 QUALIFICATIONS

- A. Installer: Company specializing in performing work of this section.

1.7 AMBIENT CONDITIONS & WEATHER LIMITATIONS

- A. Section 015000 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.
- B. Do not place asphalt mixture when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.
- C. Place asphalt mixture when temperature is not more than 15 degrees F less than initial mixing temperature.
- D. Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer and NCDOT RS. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Don not commence marking until the pavement is sufficiently dry.

1.8 TRAFFIC CONTROLS

- A. Contractor shall provide traffic controls in accordance with MUTCD as required to perform all work.

PART 2 - PRODUCTS

2.1 ASPHALT PAVING

- A. Asphalt Materials: Provide asphalt materials including binder, cement, primer, tack coat, in accordance with NCDOT RS. Recycled asphalt pavement material may be used as permitted by NCDOT RS.
- B. Aggregate Materials: Provide aggregate materials, including Coarse Aggregate, Fine Aggregate, and Mineral Fillers in accordance with NCDOT RS.
- C. Aggregate Subbase: Provide in accordance with NCDOT RS.

2.2 MIXES

- A. Use dry material to avoid foaming. Mix uniformly.
- B. Asphalt Paving Mixtures: Provide as indicated on the drawings and in accordance with NCDOT RS.

2.3 PAVEMENT MARKINGS AND SIGNAGE

1. Provide pavement markings and paint as indicated on the drawings and in accordance with NCDOT RS and the MUTCD. Pavement parking and striping paint shall be white unless indicated otherwise. Materials shall be designed for a life expectancy of at least 3 years.
2. For intersections and roadway areas provide thermoplastic compound markings and striping as indicated. No glass beads required.
3. For parking lot areas, provide water based paints only. Water based paints shall have a durability rating of at least 4 when determined in the wheel path area.
4. Provide traffic signage as indicated on the drawing and as required in accordance with NCDOT RS and MUTCD.

2.4 CONCRETE WHEEL STOPS

1. Provide wheel stops as indicated on the drawings. Manufacture with air entrained concrete having minimum compressive strength of 3,000 psi at 28 days, with two No. 4 reinforcing rods located at mid-point of its cross section.

2.5 ACCESSORIES

- A. Geotextile Fabric: Where indicated on the plans, provide AASHTO M288; non-woven, polypropylene.

2.6 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Submit proposed mix designs for review prior to beginning of Work.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify utilities indicated under paving are installed with excavations and trenches backfilled and compacted.
- C. Verify compacted subgrade and/or subbase is dry and ready to support paving and imposed loads.
 1. Proof roll subbase with in minimum two perpendicular passes to identify soft spots.
 2. Remove soft subbase and replace with compacted fill as specified in Section 312213 Grading.

- D. Verify gradients and elevations of subgrade and/or subbase are correct.
- E. Verify catch basins, manhole frames and other utility structures are installed in correct position and elevation.

3.2 PREPARATION

- A. Prepare subbase in accordance with NCDOT RS.

3.3 DEMOLITION

- A. Saw cut and notch existing paving as indicted on Drawings and as required to complete scope of work.
- B. Clean existing paving to remove foreign material, excess joint sealant and crack filler from paving surface.
- C. Repair surface defects in existing paving to provide uniform surface to receive new paving.

3.4 INSTALLATION

- A. Subgrade:
 - 1. Install and prepare subgrade in accordance with Section 312213 Grading.
- B. Subbase:
 - 1. Install and Prepare subbase in accordance with NCDOT RS. Compact base course at optimum moisture content to 100 percent ASTM D1557 maximum dry density.
- C. Primer:
 - 1. Apply primer in accordance with NCDOT RS.
- D. Tack Coat:
 - 1. Apply tack coat in accordance with NCDOT RS.
 - 2. Coat surfaces of manhole , catch basin and other utility structure frames with oil to prevent bond with asphalt paving. Do not tack coat these surfaces.
- E. Asphalt Paving:
 - 1. Install Work in accordance with NCDOT RS.
 - 2. Place asphalt within 24 hours of applying primer or tack coat.
 - 3. Place asphalt courses to compacted thicknesses as indicated on the drawings.
 - 4. Compact paving by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.

5. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.
- F. Pavement Patches
 1. Provide pavement patches for existing pavements where required for installation of utility trenches. Saw cut 12 inches beyond edge of trench. Thickness of pavement materials shall be equal to or greater than the existing pavement section.
- G. Pavement Markings and Signage
 1. Install in accordance with NCDOT RS, MUTCD, and manufacturers recommendations.

3.5 TOLERANCES

- A. Section 014000 - Quality Requirements: Tolerances.
- B. Flatness: Maximum variation of 1/4 inch measured with 10 foot straight edge.
- C. Scheduled Compacted Thickness: Within 1/4 inch.
- D. Variation from Indicated Elevation: Within 1/2 inch.

3.6 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting, testing.
- B. Testing of Aggregate Base Course:
 1. Sampling and testing shall be in accordance with ASTM D75/D75M
 2. Gradation: ASTM C136/C136M
 3. Visual: Surface shall be smooth with no ruts.
 4. Density: ASTM D1556 or ASTM 6938. One field test for every 1000 square yards; minimum 2 tests. ASTM D1557, Method D; one laboratory test for the project.
 5. Thickness: Confirm in-place compacted thickness. Acceptable tolerances are plus or minus 0.5 inches. One test for every 500 square yards, minimum of 2 tests.
- C. Testing of Pavement Course:
 1. Take samples and perform tests including mat density tests in accordance with NCDOT RS
 2. Asphalt Paving Mix Temperature: Measure temperature at time of placement.

3. Asphalt Paving Thickness: ASTM D3549; test one core sample from every 1000 square yards compacted paving; minimum 2 tests.
4. Asphalt Paving Density: ASTM D1188 or ASTM D2726; test one core sample from every 1000 square yards compacted paving ; minimum 2 tests
5. Asphalt Paving Density: ASTM D2950 nuclear method; test one location for every 1000 square yards compacted paving; minimum 2 tests
6. Asphalt Straightness: Test compacted surface of each asphalt course with a straight edge as work progresses. Apply a straight edge parallel with and at right angles to center line after final rolling.

3.7 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Immediately after placement, protect paving from mechanical injury until surface temperature is less than 140 degrees F.

END OF SECTION 321216

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SECTION 32 14 00**UNIT PAVING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Concrete pavers set in sand setting beds.
 - 2. Detectable Warning Pavers
 - 3. Steel edge restraints.
- B. Related Requirements:
 - 1. Section 321313 "Concrete Paving" for concrete base under unit pavers.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For materials other than water and aggregates.
- B. Product Data: For the following:
 - 1. Pavers.
 - 2. Sand Setting Bed
 - 3. Edge restraints.
- C. Samples for Initial Selection: For each type of unit paver indicated and the following:
 - 1. Joint materials involving color selection.
 - 2. Exposed edge restraints involving color selection.
- D. Samples for Verification: For full-size units of each type of unit paver indicated. Assemble no fewer than five Samples of each type of unit on suitable backing and grout joints. Include Samples of the following:

1. Joint materials.
2. Exposed edge restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.
- B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.

1.6 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, Samples of flooring materials that will contact or affect mortar and grout that contain latex additives.
 1. Use manufacturer's standard test methods to determine whether mortar and grout materials will obtain optimal adhesion with, and will be nonstaining to, installed brick and other materials constituting brick flooring installation.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

1.9 FIELD CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 CONCRETE PAVERS

- A. Products: Available manufacturers offering products that may be incorporated into the Work include, but are limited to the following.
 - 1. Hanover Prest Pavers
- B. Concrete Pavers: Solid paving units made from normal-weight concrete with a compressive strength not less than 8500 psi water absorption not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.
 - 1. Thickness: 1-1/2"
 - 2. Face Size and Shape: 24" x 48" nominal, rectangle.
 - 3. Color: As selected by Architect from manufacturer's full range.

2.3 DETECTABLE WARNING MATERIALS

- A. Detectable Warning Paver: Precast, designed to meet current ADA guidelines, made from Portland cement, fine and coarse aggregates, hydraulically pressed under 1000 pounds per square inch. Nominal size to be 12" by 12" by 1 1/4" or as shown on the drawings.
 - 1. Color – dark gray
 - 2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hanover Architectural Products
 - b. Pavestone Company.
 - c. Wausau Tile, Inc.
 - d. Tile Tech Pavers.

2.4 CURBS AND EDGE RESTRAINTS

- A. Steel Edge Restraints: Manufacturer's standard painted steel edging 1/4 inch thick by 5 inches high with loops pressed from or welded to face to receive stakes at 36 inches o.c. and steel stakes 15 inches long for each loop.
 - 1. Color: As selected by Architect from manufacturer's full range.

2.5 AGGREGATE SETTING-BED MATERIALS

- A. 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.
- B. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 sieve.
 - 1. Provide sand of color needed to produce required joint color.
- C. Drainage Geotextile: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:
 - 1. Survivability: Class 2, AASHTO M 288.
 - 2. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D 4751.
 - 3. Permittivity: 0.28 Sec-1, minimum; ASTM D 4491.
 - 4. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
- D. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
- B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

3.3 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
 - 1. For concrete pavers, a block splitter may be used.
- D. Joint Pattern: Running bond.
- E. Tolerances: Do not exceed 1/32-inch unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet from level, or indicated slope, for finished surface of paving.
- F. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
 - 1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
 - 2. For metal edge restraints with top edge exposed, drive stakes at least 1 inch below top edge.

3.4 AGGREGATE SETTING-BED APPLICATIONS

- A. Place separation geotextile over concrete base where all weeps and joints occur, extend at least 12 inches beyond edges and turn up at edges where applicable.
- B. Place leveling course and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.
- C. Treat leveling course with herbicide to inhibit growth of grass and weeds.
- D. Set pavers with a minimum joint width of 1/16 inch and a maximum of 1/8 inch, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch with pieces cut to fit from full-size unit pavers.

1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
- E. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
1. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches of uncompacted pavers adjacent to temporary edges.
 2. Before ending each day's work, compact installed concrete pavers except for 36-inch width of uncompacted pavers adjacent to temporary edges (laying faces).
 3. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches of laying face.
 4. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
- F. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
- G. Do not allow traffic on installed pavers until sand has been vibrated into joints.
- H. Repeat joint-filling process 30 days later.

3.5 REPAIRING AND CLEANING

- 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.

END OF SECTION 321400

SECTION 321623 – CONCRETE SIDEWALKS AND CURBS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Concrete paving for sidewalks.
 - 2. Concrete paving for curbs and gutters

- B. Related Requirements:

The following sections have work that is directly related to this Section. This does not relieve the Contractor of their responsibility to properly coordinate all work.

- 1. Section 033000 - Cast-in-Place Concrete: Cast-in-place or in-situ concrete for structural building frames, slabs on fill or grade, and other concrete components.
- 2. Section 312213 - Grading: Preparation of Site for paving and base grade.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Refer to Section 012000 - Price and Payment Procedures:

1.3 REFERENCE STANDARDS

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M182 - Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.
- B. American Concrete Institute:
 - 1. ACI 304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- C. ASTM International:
 - 1. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - 2. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - 3. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 4. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - 5. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
 - 6. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic-Cement Concrete.

7. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete.
8. ASTM C172/C172M - Standard Practice for Sampling Freshly Mixed Concrete.
9. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
10. ASTM C231/C231M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
11. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
12. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
13. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
14. ASTM D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
15. ASTM D5893/D5893M - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.

1.4 PREINSTALLATION MEETINGS

- A. Refer to Section 013000 - Administrative Requirements: Requirements for preinstallation meeting.

1.5 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 1. Submit required information regarding concrete materials, joint filler, admixtures, and curing compounds.
 2. Mix Design:
 - a. Submit concrete mix design for each concrete strength prior to commencement of Work.
 - b. Submit separate mix designs if admixtures are required for hot- and cold-weather concrete Work.
 - c. Identify mix ingredients and proportions, including admixtures.
 3. Identify chloride content of admixtures and whether or not chloride was added during manufacture.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.6 QUALITY ASSURANCE

- A. Perform Work according to Sections 033000 - Cast-in-Place Concrete.
- B. Obtain cementitious materials from same source throughout.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section.
- B. Installer: Company specializing in performing Work of this Section.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

1.9 AMBIENT CONDITIONS & WEATHER LIMITATIONS

- A. Section 015000 - Temporary Facilities and Controls: Requirements for ambient condition control facilities for product storage and installation.
- B. Minimum Conditions: Do not place concrete if base surface temperature is less than 40 deg. F or greater than 40 deg. F and falling. , or if surface is wet or frozen.
- C. Maximum Conditions: The temperature of the concrete as places shall not exceed 85 deg. F except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, as necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 95 deg. F at any time.
- D. Subsequent Conditions: Maintain minimum 50 deg. F, for not less than 72 hours after placing, and at a temperature above freezing for remainder of curing period.

1.10 EXISTING CONDITIONS**A. Field Measurements:**

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS**2.1 MATERIALS****A. Form Work:**

1. Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations within the tolerances specified.

B. Form Material:

1. Forms shall be of wood or steel, straight, or sufficient strength to resist springing during depositing and consolidating concrete.
2. Wood forms shall be surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits, and other defects. Wood forms shall have a nominal length of 10 feet.
3. Radius bends may be formed with $\frac{3}{4}$ inch boards, laminated to the required thickness.
4. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and not less than two intermediate points. Ends of steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 10 feet with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

C. Sidewalk Forms:

1. Height: Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

D. Curb and Gutter Forms

1. Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders of thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur within the return or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In

lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

E. Expansion Joint Filler:

- a. Type: Premolded compressible.
- b. Thickness: 1/2 inch.
- c. Comply with ASTM D1752.

F. Contraction Joint Filler

- a. Contraction Joint Filler for Curb and Gutter shall consist of hard-pressed fiberboard.

G. Joint Sealants

- a. Joint sealant, cold-applied shall conform to ASTM C920 or ASTM D5893/D5893M.

H. Reinforcement:

1. Reinforcing Bars:

- a. Steel: Comply with ASTM A615/A615M.
- b. Yield Grade: 60 ksi .
- c. Billet Bars: Plain or Deformed.
- d. Finish: Uncoated.

2. Welded Plain-Wire Fabric:

- a. Comply with ASTM A1064/A1064M.
- b. Configuration: Flat sheets or Coiled rolls.
- c. Finish: Uncoated.

3. Tie Wire:

- a. Type: Annealed.
- b. Minimum Size: 16 gage
- c. Finish: Uncoated.

I. Concrete:

1. Concrete Materials:

- a. As specified in Section 033000 - Cast-in-Place Concrete.

2.2 MIXES

A. Concrete:

1. Mix concrete according to ACI 304, and deliver concrete according to ASTM C94/C94M.
2. Mix Design:
 - a. Compressive Strength: 3500 psi at 28 days.
 - b. Slump: 2 to 4 inches
 - c. Maximum Water/Cement Ratio: 0.45.
 - d. Air Entrainment: 5 to 7 percent.
 - e. Maximum Aggregate Size: 1-1/2 inches
3. Admixtures:
 - a. Use accelerating admixtures in cold weather only if approved by Architect/Engineer in writing.
 - b. Use of admixtures will not relax cold-weather placement requirements.
 - c. Use calcium chloride only if approved by Architect/Engineer in writing.
 - d. Use set-retarding admixtures during hot weather only if approved by Architect/Engineer in writing.

2.3 FINISHES

2.4 ACCESSORIES

A. Curing Compound:

1. Comply with ASTM C309.

B. Cover Sheets:

1. Comply with ASTM C171, Type optional.
2. Burlap: Comply with AASHTO M182.

2.5 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for testing, inspection, and analysis.
- B. Testing: Comply with ASTM C94/C94M.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify that compacted subgrade is dry and ready to support paving and imposed loads.
- C. Verify that gradients and elevations of subgrade are as indicated on Drawings.
- D. Verify reinforcing placement for proper size, spacing, location, and support.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Moisten substrate to minimize absorption of water from fresh concrete.
- C. Notify Architect/Engineer minimum 24 hours prior to commencement of concreting operations.

3.3 INSTALLATION

- A. Subgrade:
 - 1. As specified in Section 312213 Grading.
- B. Forms:
 - 1. Place and secure forms and screeds to correct location, dimension, profile, and gradient.
 - 2. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
 - 3. Clean forms and coat with form oil each time before concrete is placed.
 - 4. Wood Forms: Thoroughly wet with water before concrete is placed.
- C. Reinforcement:
 - 1. Place reinforcing as indicated on Drawings.
- D. Placing Concrete:

As specified in Section 033000 - Cast-in-Place Concrete
- E. Sidewalk Joints:
 - 1. Sidewalk Joints shall be constructed to divide the surface into rectangular areas.

2. Place continuous transverse contraction joints at 5-foot intervals or width of sidewalk, whichever is less.
3. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 10 feet or more in width.
4. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated.
5. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using a 1/2 inch preformed joint filler of the type, thickness, and width indicated.
6. Expansion joints are not required between sidewalks and curb that about the sidewalk longitudinally.
7. Space expansion joints every 50 feet maximum, or as indicated on the drawings.
8. Contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 1/8 inch blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the job site at all times during sawing operations. Install all joints no more than 18 hours after concrete placement.
9. Expansion joints shall be formed with 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Joint filler shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius or 1/8 inch, and concrete over the joint filler shall be removed. At the end of the curing period, expansion joints shall be cleaned and filled with cold-applied joint sealant. Joint sealant shall be gray or stone in color. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 deg. F at the time of application of the joint sealant material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

F. Curb and Gutter Joints

1. Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

2. Contraction joints shall be constructed directly opposite contraction joints in abutting Portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet or greater than 15 feet in length.
3. Contraction joints (except for slip forming) shall be constructed by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after the concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.
4. When slip forming is used, the contractor joints shall be cut in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb, using a power-driven saw. The depth of cut shall be at least one-fourth of the gutter/curb depth and 1/8 inch in width.

Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement pavement and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut Portland cement concrete pavement, expansion joints at least 1/2 inch in width shall be provided at intervals not less than 30 feet or greater than 120 feet. Expansion joints shall be provided in non-reinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of concrete or as soon thereafter as weather conditions permit. Expansion joints and the top 1 inch depth of curb and gutter contraction-joints shall be sealed with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 50 deg. F at the time of application of the joint sealant material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

G. Finishing:

1. Exposed surfaces shall be floated and finished with a smooth wood float until true grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, the face of curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of the gutter and entrance shall be banished to grade with a wood float.

H. Curing:

1. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete. Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete

from rain and flowing water. All equipment needed for adequate curing and protection of concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

2. Mats:

- a. Cover exposed surface with two or more layers of wetted burlap, overlapping each other minimum 6 inches.
- b. Maintain burlap continuously saturated and in contact with concrete for minimum seven days.

3. Impervious Sheeting:

- a. Wet exposed surface and cover with impervious sheeting material, overlapped minimum 12 inches
- b. Maintain sheet in contact with concrete for minimum seven days.

4. Membrane Curing:

- a. Apply membrane-curing compound uniformly to exposed surface after free water has disappeared from finished surface and before concrete has dried.
- b. Apply compound in two coats, with second coat applied perpendicular to first coat.
- c. If concrete has dried, moisten dried surface and apply curing compound as soon as free water disappears.

- I. Backfilling: After curing, backfill, grade, and compact adjacent disturbed area as indicated.

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Requirements for tolerances.
- B. Maximum Variation of Surface Flatness: 1/4 inch in 10 feet.
- C. Maximum Variation from True Position: 1/4 inch.
- D. Line and Grade for Forms: 1/8 inch in any 10-foot- long section.
- E. Thickness: 1/4 inch.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.

- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Inspection and Testing:
 - 1. Comply with ASTM C94/C94M.
 - 2. Samples:
 - a. Sampling Procedures: Comply with ASTM C172/C172M.
 - b. Cylinder Molding and Curing Procedures: Comply with ASTM C31/C31M,
 - c. Sample concrete and make one set of three cylinders for every 150 cu. yd. or less of each class of concrete placed each day, and for every 5,000 sq. ft. of surface area paving.
 - d. Make one additional cylinder during cold-weather concreting, and field cure.
 - 3. Cylinder Compressive Strength:
 - a. Comply with ASTM C39/C39M.
 - b. Acceptance: Average Compressive Strength of Three Consecutive Tests: Maximum 500 psi less than specified compressive strength.
 - c. Test one cylinder at seven days, and two cylinders at 28 days.
 - d. Dispose of remaining cylinders if testing is not required.
 - 4. Slump, Temperature, and Air Content:
 - a. Measure for each compressive-strength concrete sample.
 - b. Slump: Comply with ASTM C143/C143M.
 - c. Air Content: Comply with ASTM C173/C173M or C231/C231M.
 - d. Temperature: Comply with ASTM C1064/C1064M.
 - 5. Records:
 - a. Maintain records of placed concrete items.
 - b. Record date, location of pour, quantity, air temperature, number of test samples taken.

3.6 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, rain and flowing water, and mechanical injury.
- C. Do not permit traffic over paving for minimum 7 days after finishing or until 90 percent design strength of concrete has been achieved whichever is longer.

D. Damaged Concrete:

1. Remove and reconstruct concrete that has been damaged for entire length between scheduled joints.
2. Refinishing damaged portion is not acceptable.
3. Dispose of damaged portions.

END OF SECTION 321623

SECTION 32 33 00**SITE FURNISHINGS****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. Bicycle racks.
 - 2. Trash receptacles.
 - 3. Bollards.
- B. Related Requirements:
 - 1. Section 033000 "Cast-in-Place Concrete" for installing pipe sleeves cast, installing anchor bolts cast, and formed voids in concrete footings.
 - 2. Section 312000 "Earth Moving" for excavation for installing concrete footings.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For each exposed product and for each color and texture specified.
- C. Samples for Initial Selection: For units with factory-applied finishes.
- D. Samples for Verification: For each type of exposed finish, not less than 6-inch- long linear components and 4-inch square sheet components.
 - 1. Include full-size Samples of bicycle rack, and trash receptacle. Approved samples may be incorporated into the Work.
- E. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Trash Receptacle Inner Containers: Five full-size units for each size indicated, but no fewer than two units.

PART 2 - PRODUCTS

2.1 BICYCLE RACKS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by manufacturer or local fabricator with minimum 5 years production experience in metal fabrication for exterior conditions.
- B. Bicycle Rack Construction:
 - 1. Frame: Stainless steel.
 - a. Tubing OD: Not less than 1-1/2 inches.
 - 2. Style: As indicated.
 - 3. Installation Method: Cast in concrete.
- C. Stainless-Steel Finish: No. 6.

2.2 TRASH RECEPTACLES

- A. Products: Available manufacturers offering products that may be incorporated into the Work include, but are limited to the following:
 - 1. Forms and Surfaces: Universal Litter & Recycling Receptacle
- B. Stainless-Steel Facing Surrounds: Steel sheet.
- C. Support Frames: Galvanized steel; welded.
- D. Trash Receptacles:
 - 1. Receptacle Shape and Form: Round cylinder; with opening for depositing trash in side of lid.

2. Lids and Tops: Matching facing permanently secured.
 - a. Description: Elevated flat or shallow dome rain-cap lid.
 3. Receptacle Height: 40.8"
 4. Overall Width: 21.5"
 5. Weight: 52 lbs
 6. Inner Rigid split stream plastic container with drain holes; designed to be removable and reusable.
 7. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
 8. Capacity: Not less than 36 gal; Split Stream
 9. Service Access: Fixed lid or top, side access; inner container and disposable liner lift or slide-out for emptying; keyed lock with two keys per receptacle.
- E. Stainless-Steel Finish: As selected from Manufacturer's full range.
- F. Graphics: Surface-applied copy, content, and style as selected from manufacturer's full range of styles.
1. Copy: Litter, Recycling

2.3 BOLLARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Selux Corporation.
 2. Philips Gardco, Inc.
 3. Hess America
- B. Basis of Design: Selux,
- C. Bollard Construction:
1. Pipe OD: As indicated on drawings
 - a. Stainless Steel: Pipe.
 2. Style: As indicated: Stainless steel fixed bollards with flush cap.
 3. Overall Height: As indicated.
 4. Overall Width: As indicated.
 5. Overall Depth: As indicated.
 6. Installation Method: Cast in concrete, as indicated.
- D. Stainless-Steel Finish: Directional Satin No. 4.

2.4 FABRICATION

- A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
- B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
- C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
- D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWWA M4 to cut surfaces.
- E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
- F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.5 GENERAL FINISH REQUIREMENTS

- A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 STAINLESS-STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1. Run directional finishes with long dimension of each piece.
 - 2. Directional Satin Finish: No 4.
 - 3. Dull Satin Finish: No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
- B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
- C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.
- D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.
- E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.
- F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION 323300

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SECTION 32 84 00**PLANTING IRRIGATION****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1. 012100 – Allowances
2. 22113 – Facility Water Distribution Piping

1.2 SUMMARY

- A. The Drawings and Specifications herein apply to the Point of Connection and downstream.

- B. Section Includes:

1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Quick couplers.
11. Drip irrigation specialties.
12. Controllers.
13. Boxes for automatic control valves.

DEFINITIONS

- C. Irrigation Supply: Upstream of the Point of Connection, the irrigation supply includes the existing well.
- D. Point of Connection: Defined as the below ground discharge from the existing well

- E. Irrigation System: Defined as components of the system that are located immediately downstream of the point of connection.
- F. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
- G. System Main Feed – The piping and fittings required to move water from the Point of Connection to 5' beyond the Main Isolation Valve
- H. Main Isolation Valve – A master valve capable of shutting off the entire system before the system main splits - as located on the plan.
- I. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
- J. 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.

1.3 PERFORMANCE REQUIREMENTS

- A. This Section describes work downstream of the Irrigation Supply (existing well).
- B. The design must meet the following design guidelines:
 - 1. Requirements supplied by the Wilmington, NC.
- C. Irrigation zone control shall be automatic operation with controller and automatic control valves.
- D. High rate delivery systems such as flood bubblers are not allowed.
- E. Provide only high efficiency equipment capable of providing water accurately and efficiently. The system shall use drip irrigation for plants and spray for turf.
- F. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and lights.
- G. No valves, fittings, or joints are to be placed under paved surfaces, curbs or sidewalks. Where possible, crossing shall be uninterrupted stretches of pipe within sleeves sized according to the drawings.
- H. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
 - 1. Irrigation System Feed: 400 psig.
 - 2. Irrigation Main Piping and Circuit Piping: 200 psig .
- I. The following are soil conditions found at the site:

- a. Structure: The soil structure of the site is compacted due to working and construction activity. This compaction will reduce standard infiltration rates.
- b. Infiltration Rate:
 - 1) Clay: .2-.3 in/hr.

- J. Drip Emitters Per Plant – use the following guide to set the number of emitters per plant, based upon a 2 hour watering window [WW] and delivering matched water delivery per zone.

TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS

Type of plant	Plant Size at installation	Gal. Per week [X]	Gal / W W	Minimum # emitters per plant	# emitters per plant at .5 gph	# emitters per plant at 1.0 gph	# emitters per plant at 1.5 gph	# emitters per plant at 2.0 gph	# emitters per plant at 3.0 gph
Tree	5-7" caliper tree	100	7.1	6	14	7	5	4	2
	2.5" to 4" caliper	60	4.3	4	9	4	3	2	1
Shrub	8-10' BB shrub	40	2.9	4	6	3	2	1	1
	5-7' BB shrub	20	1.4	3	3	2	1	1	N/A
	3-6' container shrub	10	0.7	2	2	2	N/A	N/A	N/A
	8" – 30" shrub or groundcover	7	0.5	1	1	1	N/A	N/A	N/A
Grasses and Perennials	Quart size plant	5	0.4	1	1	N/A	N/A	N/A	N/A
Plugs	4" pot and less	3		Grid of drip. See below					
• Minimum emitters per plant equals what is required to fully wet the root ball perimeter, not just one side • Emitters should be placed 4-6" inside the root ball • N/A – less than one emitter which is not possible									

- Grid of drip should be the same rate as the plant spacing
- The Contractor shall use this table as a guide. Provide refinement of the system for different plant types and varying soil conditions.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Equipment Numbering System
- C. Use a coordinated numbering system for shop drawings, as-builts and field labeling as follows:
 - 1. Drip Valves – Use 51-99
 - 2. Valves, Pressure Regulators & Other Equipment - Use 100 and above
- D. Delegated-Design Submittal [Shop Drawings]: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional designer responsible for their preparation. Submittal should include irrigation systems, drawn to scale in a CAD software (contact the Landscape Architect for CAD backgrounds), showing the following:
 - 1. Main piping
 - 2. Circuit piping
 - 3. Automatic control valves
 - 4. Point of Connection location
 - 5. Time clock and rain sensor location
 - 6. Blow-off valves, isolation valves, quick coupler connections,
 - 7. Numbered valves with GPM calculated for each
 - 8. Coordination with site elements and utilities.
 - 9. Required Pressure at Point of Connection – The irrigation designer shall state the pressure required of irrigation system in PSI.
 - 10. Irrigation pump
 - 11. System Pressure Loss – The designer shall state the calculated pressure loss from the Point of Connection to the furthest automated valve in PSI on the drawing.

1.5 INFORMATIONAL SUBMITTALS

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

1.6 CLOSEOUT SUBMITTALS

- A. System Manual: A hard cover, 3 ring bound, exterior project titled, with table of contents for sprinklers, controllers, pumps, quick couplers, rain sensors, and automatic control valves to include the following:
 - 1. Product cut sheets designating exact model number(s)
 - 2. Written schedule of operation including a winterization date, start up date, and controller timing schedule suggestions for spring, summer, and fall.
 - 3. Operation and Maintenance information of the provided equipment including a schedule of routine maintenance for cleaning and adjusting equipment.
 - 4. Reduced as-built plans bound with in the manual or in plastic sleeves.
- B. Prepare an as-built CAD drawing of the installed system. The drawings shall be legible with no overlapping or hidden graphics. Provide enlargements of crowded or obscured areas. Take field measurements and indicate on the drawings the dimensions of key elements from known site points such as the buildings and roadways to showing installed conditions of the following equipment:
 - 1. Main lines and lateral lines
 - 2. Automatic valves, manual valves, blow-offs and quick couplers
 - 3. Pump, time clock and rain sensor
 - 4. Circuit and sensor wires
 - 5. Valve numbers corresponding to the time clock labeling, zone designation, and GPM for each zone.

1.7 MATERIALS MAINTENANCE SUBMITTALS [ATTIC STOCK]

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Drip-Tube System Tubing: Equal to 2% percent of total length installed for each type and size indicated, but not less than 100 feet.
 - 2. Drip emitters – provide 10 of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers that include a [certified irrigation designer qualified by The Irrigation Association] [Professional Class member of the American Society of Irrigation Consultants] [Professional Technical Class member of the American Society of Irrigation Consultants] <Insert qualifications>.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.10 PROJECT CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Architect and Owner no fewer than two days in advance of proposed interruption of water service.
 - 2. Do not proceed with interruption of water service without Owner's written permission.
 - 3. Do not proceed with irrigation work until rough grade approval is given by the Landscape Architect.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes. Supply components having pressure rating equal to or greater than system operating pressure.
- B. Underground irrigation System Main Feed shall be the following:
 - 1. Schedule 80, PVC socket fittings; and solvent-cemented joints.
- C. Underground irrigation Main Piping shall be the following:
 - 1. SDR 200, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
- D. Circuit piping shall be the following:
 - 1. SDR 200, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
- E. Risers to Aboveground drip lines: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

2.2 PIPING JOINING MATERIALS

- A. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656. Use a color tinted material.

2.3 MANUAL VALVES

A. Plastic Ball Valves:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Valve, Inc.
 - b. Asahi/America, Inc.
 - c. Colonial Engineering, Inc.
 - d. Fischer, George Inc.
 - e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
 - f. IPEX Inc.
 - g. Jomar International, LTD.
 - h. KBI (King Bros. Industries).
 - i. Legend Valve.
 - j. NIBCO INC.
 - k. Sloane, George Fischer, Inc.
 - l. Spears Manufacturing Company.
 - m. Thermoplastic Valves Inc.
 - n. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating: 200 psig .
 - c. Body Material: PVC.
 - d. Type: Union.
 - e. End Connections: Socket or threaded.
 - f. Port: Full.

2.4 PRESSURE-REDUCING VALVES

A. Water Pressure Regulators:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cash Acme; a division of The Reliance Worldwide Corporation.

- b. Conbraco Industries, Inc.; Apollo Valves.
- c. Honeywell International Inc.
- d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- e. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

- a. Standard: ASSE 1003.
- b. Body Material: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved.
- c. Pressure Rating: Initial pressure of 150 psig .
- d. End Connections: Threaded for NPS 2 and smaller.

2.5 AUTOMATIC CONTROL VALVES

A. Low Flow Drip Control Valves :

- 1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid. For flow ranges below 5 gpm.
- 2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Buckner; a division of Storm Manufacturing Group Inc.
 - b. Ceres Products Company.
 - c. Champion Irrigation Products.
 - d. Dig Corporation.
 - e. Greenlawn Sprinkler Company.
 - f. Hit Products Corporation.
 - g. Hunter Industries Incorporated.
 - h. Irritrol Systems.
 - i. Nelson, L. R. Corporation.
 - j. Netafim USA.
 - k. Olson Irrigation Systems.
 - l. Orbit Irrigation Products, Inc.
 - m. Rain Bird Corporation.
 - n. Superior Controls Co., Inc.
 - o. Toro Company (The); Irrigation Division.
 - p. Weathermatic.

2.6 AUTOMATIC DRAIN VALVES

- A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig .

2.7 TRANSITION FITTINGS

- A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Transition Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cascade Waterworks Manufacturing.
 - b. Dresser, Inc.; DMD Division.
 - c. Ford Meter Box Company, Inc. (The).
 - d. JCM Industries.
 - e. Smith-Blair, Inc; a Sensus company.
 - f. Viking Johnson.
 - 2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
- C. Metal to Plastic Transition Fittings at Point of Connection:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Harvel Plastics, Inc.
 - b. Spears Manufacturing Company.
 - 2. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket or threaded end.

2.8 MISCELLANEOUS PIPING SPECIALTIES

- A. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
- B. Pressure Gages: ASME B40.1. Include 4-1/2-inch- diameter dial, dial range of two times system operating pressure, and bottom outlet.
- C. Detectable Warning Tape: Provide detectable warning tape with "IRRIGATION LINE" clearly marked and a unique color.

2.9 QUICK COUPLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hunter Industries Incorporated.
 2. Nelson, L. R. Corporation.
 3. Rain Bird Corporation.
 4. Toro Company (The); Irrigation Division.
 5. Weathermatic.
- B. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap;
- C. Key – Provide factory-fabricated brass one piece swiveling connector with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet. Provide one key per installed quick coupler with a minimum number of two.

2.10 RAIN SENSOR

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Hunter Industries Incorporated.
 2. Nelson, L. R. Corporation.
 3. Rain Bird Corporation.
 4. Toro Company (The); Irrigation Division.
 5. Weathermatic.
- B. Description: UL listed, UV stabilized plastic housing rain sensor with the following properties:
1. Hardwire installation
 2. 2-5 minute time duration to system shut down
 3. Time to reset should be less than 4 hours
 4. Operating temperature range 32 – 130 degrees
 5. 24 volt, 3amp
 6. Matched to controller station
 7. Selectable rain shut off indexes at 1/8", 1/4", 1/2". 3/4" of rainfall

2.11 DRIP IRRIGATION SPECIALTIES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Agrifim.

2. Aquarius Brands, Inc.
 3. Buckner; a division of Storm Manufacturing Group Inc.
 4. Dig Corporation.
 5. Geoflow, Inc.
 6. Hendrickson Bros.
 7. Hit Products Corporation.
 8. Irritrol Systems.
 9. Maxijet, Inc.
 10. NDS/Raindrip.
 11. Netafim USA.
 12. Olson Irrigation Systems.
 13. Orbit Irrigation Products, Inc.
 14. Rain Bird Corporation.
 15. Roberts Irrigation Products, Inc.
 16. Salco Products.
 17. Toro Company (The); Irrigation Division.
- B. On-line [on pipe] Emitter Systems:
1. Tubing: Black PE tubing UV resistant.
 2. Emitter: Attached to pipe drip device .
 - a. Body Material: UV Resistant PE or Vinyl
 - b. Design Flow: .5 to 2.0 gph.
 - c. Pressure compensating from 7-50 psi
 - d. Minimum operation pressure if 15 psi
 - e. Minimum filtration 120 mesh
 - f. Self flushing design
 - g. Includes an internal low pressure 1.5 psi check valve
- C. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 , with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig .
- D. Filter Units: Plastic housing with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
1. Provide screening to 120 mesh size.
 2. Minimum size 3/4"
 3. Flow Range 1-12 gpm
 4. maximum pressure 140 psi
 5. Polyamide staking ring type filter
- E. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
- F. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

2.12 CONTROLLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Buckner; a division of Storm Manufacturing Group Inc.
 2. Champion Irrigation Products.
 3. Hit Products Corporation.
 4. Hunter Industries Incorporated.
 5. Irritrol Systems.
 6. K-RAIN Manufacturing Corporation.
 7. Nelson, L. R. Corporation.
 8. Netafim USA.
 9. Orbit Irrigation Products, Inc.
 10. Rain Bird Corporation.
 11. Superior Controls Co., Inc.
 12. Toro Company (The); Irrigation Division.
 13. Weathermatic.
- B. Description:
1. General: Time clocks must provide the following features:
 - a. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily
 - b. A minimum of programming three fully independent programs with four start times per program.
 - c. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation
 - d. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 120 minutes. Include switch for manual or automatic operation of each station
 - e. Quantity of stations equal to the zones required plus 4 empty zones.
 - f. Rain Sensor: Adjustable from one to seven days, to shut off water flow during rain
 - g. Non-volatile memory for holding programs during power outages
 - h. 120 volt input, 24 VAC output
 - i. Control Transformer: 24-V secondary, with primary fuse
 - j. Surge Protection: Metal-oxide-varistor type on each station and primary power
 - k. With a cistern, pump start capability
 - l. Hand held remote included with system
 - m. Lockable cabinet with two matching keys.
 2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof and provision for grounding.
 - a. Body Material: Enameled-steel sheet metal or Stainless-steel sheet metal
 - b. Mounting: Freestanding type for concrete base.

3. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
 - a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
4. Concrete Base: Reinforced precast concrete not less than [36 by 24 by 4] inches thick. Include opening for wiring.

2.13 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Nationwide Plastics, Inc.
 - d. NewBasis.
 - e. Oldcastle, Inc.
 - f. Orbit Irrigation Products, Inc.
 - g. USFilter/Plymouth Products, Inc.
2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.
 - b. Shape: Round and rectangular
 - c. Sidewall Material: Structural foam plastic.
 - d. Cover Material: Structural foam plastic
 - e. UV resistant
 - f. Stainless steel screw lock
 - g. Color: black.

B. Drainage Backfill: #57 stone.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."
- B. Install detectable warning tape directly above Main Line piping only at 12" below finished grade.
- C. Provide minimum cover over top of underground piping according to the following:
 - 1. System Main Feed: Minimum depth of 30 inches below finished grade.
 - 2. Main Line Piping: Minimum depth of 18 inches below finished grade
 - 3. Circuit Piping: Minimum of 12 inches below finished grade
 - 4. Sleeves: 24 inches or 12" below finished grade or pavement gravel sub-bases, whichever is deeper
 - a. Extend sleeves 30" beyond edge of pavement.

3.2 PREPARATION

- A. Carefully mark out the extent of lawn versus planting beds to avoid spray overlap. Spray irrigation of areas other than lawns is not allowed.
- B. Confirm that the rough grades have been established prior to topsoil spreading.
- C. Examine the site compared to the system design and notify the Architect of changes.
 - 1. Submit design changes to the Architect if revisions to the design are warranted
- D. Verify existence of required sleeving.
- E. Store pipe and fitting for project in an area that will not introduce dirt and debris into the interior.

3.3 PIPING INSTALLATION

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with NPS 2 or smaller pipe connection.

- G. Install expansion loops in control-valve boxes for plastic piping.
- H. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- I. Install PVC piping in dry weather when temperature is above 40 deg F . Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.
- J. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install below ground in control-valve boxes.
- K. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
- L. Install sleeves made of Schedule 80 PVC pipe and socket fittings, and solvent-cemented joints. Extend 30" beyond pavement or curb edges.
- M. Install piping in sleeves under parking lots, roadways, and sidewalks. Avoid fittings within sleeves.
- N. Install transition fittings for plastic-to-metal pipe connections according to the following:
 - 1. Underground Piping:
 - a. NPS 1-1/2 and Smaller: Plastic-to-metal transition fittings.
 - b. NPS 2 and Larger: AWWA transition couplings.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

- E. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 3. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.5 VALVE INSTALLATION

- A. Isolation valves: Install isolation valves with handles oriented to surface.
- B. Pressure-Reducing Valves: Install in boxes for automatic control valves. Install full-size valved bypass.
- C. Automatic Control Valves: install according to manufacture's recommendations with manual adjustment handles oriented to the surface.
- D. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.6 QUICK COUPLER INSTALLATION

- A. Install quick coupler as per manufacturers' recommendations at a height below mower damage level.
- B. Install approximately 6" by 6" by 6" concrete collar underground, covered by 1" of soil.
- C. Paint exposed plastic parts black.

3.7 RAIN SENSOR INSTALLATION

- A. Hardwire connection from time clock to sensor.
- B. Place in an open area with no overhang as approved by the landscape architect or as shown on the plan.
- C. Installation should be neat with organized wiring.

3.8 DRIP IRRIGATION SPECIALTY INSTALLATION

- A. Install area connection tubes with 3" of cover and with galvanized stakes as needed.

1. For each zone provide loop back to within 10' of the first emitter.
- B. Install the number of drip emitter per plant according to TABLE 1 – DRIP SYSTEM PERFORMANCE REQUIREMENTS
- C. For Trees, large shrubs, use drip line with internal emitters on “T” loops from main line.
- D. For container shrubs choose drip line with internal emitters for regularly spaced shrubs and drip line with external emitter for irregularly spaced shrubs.
- E. For mass plantings of small containers or plugs, use a grid of drip tube with internal emitters.
- F. Install drip tubes as follows:
 1. Install on ground. Stake with galvanized stakes as needed to maintain contact.
 2. Drip tubing should be placed on the root ball, 3" from the edge and exposed.
 3. External emitters should be exposed to view.
 4. For container shrubs place beneath the mulch on the root ball.
 5. For grid layout, use a matching spacing to the planting.
- G. Install application pressure regulators and filter units in piping near zone valves below ground in boxes. Orient the regulators to assist with maintenance.

3.9 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

- ~~A. [SELECT FOR INTERIOR /EXTERIOR WALL MOUNTING] Equipment Mounting: Install interior controllers at eye level on wall.~~
- ~~0. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.~~
- ~~0. Install anchor bolts to elevations required for proper attachment to supported equipment.~~
- ~~D.A. [SELECT FOR EXTERIOR-FREESTANDING] Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.~~
1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E.B. Install control cable in same trench as irrigation piping and at least 2 inches beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas. Install warning tape during backfill operation.

3.10 CONNECTIONS

- A. Comply with requirements for piping specified in Division 22 Section "Facility Water Distribution Piping" for water supply from exterior water service piping, and protective enclosures. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
- C. Connect wiring between controllers and automatic control valves.

3.11 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Brand each valve box where isolation valve, automatic control valves, pressure regulator valve, or filter is housed with a unique name that appears on the time clock and the as-built drawings.
 - 1. Text: Minimum ½" letters branded into plastic valve box housing.
 - a. Turf Valves – Use 1-50
 - b. Drip Valves – Use 51-99
 - c. Valves, Pressure Regulators & Other Equipment - Use 100 and above
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section "Earth Moving" for warning tapes.

3.12 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. System Main Feed & Main Line Leak Test: After installation, charge system and test for leaks with a pressure indicator over a 24 hour period. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 4. Test spray heads for too little or too much pressure. Make adjustments in the system, including installing pressure compensation devices or boosting overall system pressure to provide a functioning system.
- B. Any irrigation system or product will be considered defective if it:
 - 1. Does not pass tests and inspections.
 - 2. Does not provide manufacturer's recommended pressures throughout the system

3. Does not provide complete separation of grass and planting areas [individual trees may be over sprayed]
4. Does not provide matched precipitation rates throughout the lawn
5. Does not provide drip system delivery target rates for plant types.
6. Sprays water onto pavements, buildings, or signage.
7. Does not provide for easy maintenance as follows:
 - a. Ball valves, filters, regulators are poorly oriented for hand access
 - b. Automatic Valves are poorly oriented for access
 - c. Irrigation equipment is installed at a grade that would encourage damage from mowers

C. Defective irrigation systems or components shall be repaired at no cost to the Owner.

3.13 FLUSH OUT CLEANING

- A. Flush dirt and debris from piping before installing sprinklers and other devices.
- B. Clean or replace all filters.

3.14 STARTUP SERVICE

- A. Perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that controllers are installed and connected according to the Contract Documents.
 3. Verify that electrical wiring installation complies with manufacturer's submittal.

3.15 ADJUSTING

- A. Provide at least three programmed time schedules.
 - a. One is for immediate post planting where the system is run at high rates for a short duration.
 - b. Second is for a longer term establishment period, where distribution rates are reduced but still higher for plant establishment.
 - c. Third is a long term summer schedule distributing about 1" of precipitation to lawn areas per week and 70 gallons per week to shrubs.
- B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
- C. Adjust sprinklers and devices so they will be flush with finish grade or as recommended by the manufacturer.

- D. Adjust drip system to provide gallons per week delivery targets by adding and subtracting emitters.

3.16 DEMONSTRATION

- A. Train Owner's maintenance personnel by providing the following instruction:
 - 1. Review the as-built materials with the owner
 - 2. Demonstrate how to program the clock.
 - 3. Demonstrate how to adjust heads
 - 4. Demonstrate how to clean filters and pressure regulation
 - 5. Review the site components of the system, identify valve boxes

END OF SECTION 328400

SECTION 32 92 00**TURF AND GRASSES****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sodding.
 - 2. Grass paving.
- B. Related Sections:
 - 1. Division 32 Section "Plants" for border edgings.

1.3 DEFINITIONS

- A. Substantial Completion: The proper installation of seed, sod, and meadow with final grades, mulch and irrigation functioning (if provided) with no indication of widespread plant death. For seeded and meadow areas, the seed must show germination with green shoots visible. It is possible to grant substantial completion to portions of the site without total project completion however all construction activities must be completed in the requested area.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- E. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill lawn or sod areas.

- F. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- G. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.
- H. Turf: A groundcover established from either lawn type seeds, lawn type sod or meadow seeds.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.

1.5 INFORMATIONAL SUBMITTALS

- A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- B. Qualification Data: For qualified landscape Installer.
- C. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- D. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of the Professional Landcare Network, the NC Landscape Contractors Association, or the American Nursery and Landscape Association.
 - 2. Experience: Three years' experience in turf installation in addition to requirements in Division 01 Section "Quality Requirements."

3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 4. Personnel Certifications: All personnel who handle herbicides and herbicides shall be State licensed, for commercial.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
1. Test native in place surface soil and soil components of Planting Soils Type A, B,C and D.
 2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 3. Test shall include mechanical analysis of sand, silt and clay components.
 4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 5. Soil tests shall include the following information:
 - a. Percentage of sand, silt and clay.
 - b. Cation exchange capacity.
 - c. Percent of organic matter.
 - d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.8 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.

Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

Grass Type	Fall Season	Spring Season
Warm season grasses	Sept 1 to Oct 15	May 15-July 15

B. Water Source:

1. The Owner shall provide water for:
 - a. The construction period until Substantial Completion for the last phase of work.
 - b. Substantial Completion for the last phase of work through the maintenance period.
2. The Contractor shall provide watering labor as follows:
 - a. The construction period until Substantial Completion for the last phase of work.
 - b. Substantial Completion for the last phase of work through the maintenance period.

1.9 MAINTENANCE

- A. Initial Maintenance Service for Lawns [sod and seed areas]: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin

maintenance immediately after lawns are installed and continue until plantings are acceptably healthy, well established, and deemed satisfactory per Part 3; but for not less than the Construction Maintenance Period below.

1. Construction Maintenance Period: 6 months. The Construction Maintenance Period will begin from the date of Substantial Completion for the last phase of work. Partial areas of turf deemed satisfactory per Part 3 require continued maintenance until all areas are deemed satisfactory per Part 3 and until final date of Construction Maintenance Period; whichever elapses last.
- B. Continuing Maintenance Proposal: Any agreement of an Owner with the Contractor for annual landscape services would begin after the maintenance period elapses.

PART 2 - PRODUCTS

2.1 TURFGRASS SOD

- A. Turfgrass Sod: Number 1 Quality/Premium, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
- B. Turfgrass Species:
 1. Light shade areas: Bermuda 'Celebration'
 2. Full sun areas: Bermuda TifTurf(DT-1)

2.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 1. Provide lime in form of ground dolomitic limestone or calcitic limestone depending on soil test.

2.3 ORGANIC SOIL AMENDMENTS

- A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 1. Organic Matter Content: 70 percent of dry weight.
 2. Sources: Agricultural, bark, biosolids; municipal compost; or source-separated or compostable mixed solid waste.
 - a. Free of toxic materials to plant growth

- b. Free of weed seeds.

2.4 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.5 PLANTING SOILS

- A. Planting Soil Type A: Existing, in-place surface soil. Verify suitability of existing surface soil to produce viable planting soil. Remove stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - 1. Depth of soil conditioner to mix in Planting Soil: 3/8" to 4".
 - 2. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. consult soil test.
 - 3. Weight of dolomitic limestone per soil test.
- B. Planting Soil Type B: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth by mechanical screening.
 - 1. Supplement with approved Type C topsoil when quantities are insufficient.
 - 2. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - 3. Depth of soil conditioner to mix in Planting Soil: 3/8" to 4".
 - a. Weight of Slow-Release Fertilizer as per soil test.
 - b. Weight of dolomitic limestone as per soil test.
- C. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

1. Depth of soil conditioner to mix in Planting Soil: 3/8" to 4".
2. Weight of Slow-Release Fertilizer as per soil test
3. Weight of dolomitic limestone as per soil test.

2.6 PESTICIDES

- A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.7 GRASS-PAVING MATERIALS

- A. Grass Paving: Cellular, made from recycled plastic, non-biodegradable mats, designed to contain small areas of soil and allow an 80,000 lbs fire truck loading and general service traffic. Include manufacturer's recommended anchorage system for slope conditions.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. AirPave by AirField Systems.
(<http://www.airfieldsystems.com/grass-pave/>)
 - b. Invisible Structures, Inc.; Grasspave2.
(<http://www.invisiblestructures.com/grasspave2.html>)
 - c. NDS, Inc. Tufftrack or Grasspave (
 - d. Presto Products Company, a business of Alcoa; Geoblock Porous Pavement System.
(http://www.prestogeo.com/geoblock_porous_pavement)
 - e. RK Manufacturing, Inc.; Grassy Pavers.
(<http://www.grassypavers.com/>)
- B. Base Course: As noted on details
- C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
- D. Proprietary Growing Mix: As submitted and acceptable to Architect.

- E. Sandy Loam Soil Mix: Naturally occurring sandy loam topsoil containing 60% sand, 35% silt and 5% clay, 5% by volume organic matter and free of weed seed and deleterious materials to plant growth.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance. Notify the Architect immediately and do not start landscape construction operations if:
 - 1. Grades or site features do not match the design.
 - 2. There is ponding or areas that do not appear to drain
 - 3. The subsoil contains no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 4. If the soils are frozen or moist beyond that required to produce optimal working conditions.
 - 5. Excessively dry soil that is not workable and which is too dusty.
 - 6. If the subsoil is over compacted.
 - 7. If irrigation main and lateral lines have not been installed.
 - 8. If irrigation main or lateral line trenches have not been compacted.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches.
 - 1. General
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.

- b. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 - c. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
 - d. Reduce elevation of planting soil to allow for soil thickness of sod.
- 2. Spread planting soil B, C to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- 3. Thoroughly blend planting soil with organic amendments off-site before spreading
- 4. Apply lime and fertilizers on surface, and thoroughly blend planting soil.
- C. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
- D. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- E. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR GRASS-PAVING MATERIALS

- A. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions, compact subgrade as specified in paving-material manufacturer's written instructions..
- B. Install base course and/or sand course as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.
- C. Install paving mat and fasten according to paving-material manufacturer's written instructions.
- D. Before planting, fill cells of paving mat with Grass Paving Sandy Loam Soil Mix and compact according to manufacturer's written instructions.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across angle of slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:6 or in the bottom of swales with steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.6 TURF MAINTENANCE

- A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Repair turf as necessary because of settling, erosion or settlement or other processes.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain irrigation systems, temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches .
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than

1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:

1. Mow bermudagrass to a height of 1 inch.

D. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.7 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.8 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.9 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200

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SECTION 329219 - SEEDING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fertilizing.
 - 2. Seeding.
 - 3. Mulching.
 - 4. Maintenance.
 - 5. Section 312213 - Grading

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- 1. Refer to Section 012000 Price and Payment Procedures.

1.3 REFERENCES

- A. ASTM International:
 - 1. ASTM C602 - Standard Specification for Agricultural Liming Materials.
- B. NC Department of Environmental Quality (NCDEQ)
 - 1. Erosion and Sediment Control Planning and Design Manual (ESM)

1.4 DEFINITIONS

- A. Weeds: Vegetative species other than specified species to be established in given area.

1.5 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Operation and Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer;
- C. Do not apply lime, fertilizer or seed in strong wind or when the soil is extremely wet or otherwise unworkable. No rolling shall be done if precipitation after seeding would make the operation detrimental to the seed bed.

1.7 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.
- B. Perform Work according to NCDOT standards.
- C. Maintain one copy of each document on site.
- D. Perform work in accordance with approved erosion control permit.

1.8 QUALIFICATIONS

- A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Product storage and handling requirements.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.10 MAINTENANCE SERVICE

- A. Section 017000 - Execution and Closeout Requirements: Requirements for maintenance service.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition for a minimum of two cuttings. Mow grass at regular intervals to a maximum height of 3 inches.
- C. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions.
- D. Water areas seeded between May 1 and July 15 at such intervals as to maintain the seeded area in a moist condition until the grass is established and accepted by the Engineer. Provide equipment to transport and distribute the water to the seeded areas. Areas seeded between September 1 and November 1 need not be irrigated beyond the initial watering specified above except that the Contractor may apply water at his own discretion.

PART 2 - PRODUCTS**2.1 SEED MIXTURE**

- A. Furnish temporary seed mixture according to NCDEQ ESM Section 6.10, and as indicated on drawings.
- B. Furnish permanent seed mixture according to NCDEQ ESM Section 6.11, and as indicated on drawings. A highway mix in accordance with NCDOT standards may be utilized pending approval by the Engineer.
- C. For restoration of wetland vegetation, Contractor shall provide a wetland mixture containing native grasses.

2.2 TOPSOIL

- A. Topsoil shall be fertile, agricultural soil, typical for locality, capable of sustaining virourous plant growth, taken from drained site, free of subsoil, clay or impurities, plants, weeds, and roots; pH value of minimum 5.4 and maximum of 7.0.

2.3 ACCESSORIES

- A. Mulching Material: Oat, rye or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.
- B. Fertilizer: Commercial grade; recommended for grass; of proportion necessary to eliminate deficiencies of topsoil.

- C. Lime: ASTM C602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent.
- D. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.
- E. Erosion Fabric: Jute matting, open weave held in place by staples. Approval of fabrics will require manufacturer's design data regarding velocity, ditch slopes, method of installation, decay cycle, repair techniques and grass growth enhancement characteristics.
- F. Staples: 16 gauge steel wire, with minimum of 3 inch top and 4 inch long legs.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify prepared soil base is ready to receive the Work of this section.

3.2 FERTILIZING

- A. Apply lime at application rate as indicated on drawings. Work lime into top 6 inches of soil.
- B. Apply fertilizer at application rate as indicated on the drawings.
- C. Apply after smooth raking of topsoil.
- D. Do not apply fertilizer at same time or with same machine used to apply seed.
- E. Mix fertilizer thoroughly into upper 2 to 3 inches of topsoil.
- F. Lightly water soil to aid dissipation of fertilizer. Irrigate top level of soil uniformly.

3.3 SEEDING

- A. Apply seed at rate indicated on drawings evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Planting Season: As indicated on drawings.
- D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.
- E. Roll seeded area with roller not exceeding 120 lbs/linear foot.
- F. Immediately following seeding, apply mulch. Maintain clear of shrubs and trees.
- G. Apply water with fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

3.4 SEED PROTECTION

- A. Cover seeded slopes where grade is 4 inches per foot or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.
- B. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36 inch intervals with staples.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.5 MAINTENANCE

- A. Mow grass at regular intervals to maintain at maximum height of 3 inches. Do not cut more than 1/3 of grass blade at each mowing. Perform first mowing when seedlings are 40 percent higher than desired height.
- B. Immediately remove clippings after mowing and trimming. Do not let clippings lay in clumps.
- C. Water to prevent grass and soil from drying out.
- D. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.
- E. Immediately reseed areas showing bare spots.
- F. Repair washouts or gullies.
- G. Protect seeded areas with warning signs during maintenance period.

END OF SECTION 329219

SECTION 32 93 00**PLANTS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Plants.
 - 2. Planting soils.
 - 3. Landscape edgings.
 - 4. Decorative stone
- B. Related Sections:
 - 1. Division 32 Section "Turf and Grasses" for turf (lawn)

1.3 DEFINITIONS

- A. Substantial Completion: The proper installation of plant material with final grades, mulch and irrigation (if provided) functioning with no indication of widespread plant death. It is possible to grant substantial completion to portions of the site without total project completion however all construction activities must be completed in the requested area.
- B. Backfill: The planting soil used to replace or the act of replacing earth in an excavation.
- C. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- D. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape

and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

- E. Finish Grade: Elevation of finished surface of planting soil.
- F. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- G. Planting Area: Areas to be planted.
- H. Planting Soil: The prepared earth [existing or imported as specified herein] used to backfill planting areas or to create planting beds.
- I. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- K. Stem Girdling Roots: Roots that encircle the stems (trunks) or main roots of trees below the soil surface.
- L. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- M. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- N. Environmental Conditions: Physical, chemical, and biotic factors affecting ecological community and ability for plants to survive.
- O. Detrimental Conditions: Environmental conditions harmful to the health of proposed plants that can be corrected through supplemental site improvements. Harmful conditions include, but shall not be limited to the following: poor soil, poor drainage, or contaminated soil.

1.4 ACTION SUBMITTALS

- A. Samples for Verification: For each of the following:
 - 1. Mulch: A 1-quart volume of each mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
 - 2. Gravel: 1 quart volume of each gravel matrix required, in sealed plastic bags labeled with source. Sample shall be typical of the lot of material to be delivered

- and installed on the site; provide an accurate indication of color, texture, and makeup of the material.
3. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
- B. Soil Analysis: For each un-amended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
1. Test native in place soil components of Planting Soils Type B,C and D.
 2. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 3. Test shall include mechanical analysis of sand, silt and clay components.
 4. The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 5. Soil tests shall include the following information:
 - a. Percentage of sand, silt and clay.
 - b. Cation exchange capacity.
 - c. Percent of organic matter.
 - d. Stated recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - e. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- B. Substitutions: The Contractor shall provide the products specified. Changes must be made by written submittal with reason and alternate suggestion.
- C. Environmental Conditions: Prior to contract acceptance by Contractor, submit written description of environmental conditions preventing compliance with warranty.
 1. As applicable, submit detrimental conditions and/or substitutions submittals.
- D. Detrimental Conditions: Per encounter, submit written description of detrimental conditions with recommendation for correcting condition. Include cost estimate.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 Section "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
- B. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
 - 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.
 - 2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- C. Plant Pre-Approvals: Utilize the following methods for plant selection.
 - 1. Container Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to the Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.
- D. Additional Plant Material Observation: Architect may observe plant material either at site before planting or once installed for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
- E. Substitutions: Substitutions will be permitted only upon submission of proof that a specified plant is not obtainable and with written approval of proposed substitution by Landscape Architect.
 - 1. Contractor shall propose the use of the nearest obtainable variety of the plant having the same essential characteristics that is equal to or greater in size to original specified plant.

- F. Detrimental Conditions: The contractor shall notify the Owner and Landscape Architect in writing of all conditions considered detrimental to growth of plant material. State condition and submit proposal including costs for correcting condition.
- G. Preinstallation Conference: Conduct conference at Project site.
 - 1. The following individuals must be present:
 - a. GC Contractor's site representative responsible for the Landscape Contractor's work
 - b. The Landscape Contractor's branch manager [or Owner] and job estimator.
 - c. The Project supervisor who will be directly responsible for field work and/or paperwork.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
- C. Do not prune trees and shrubs before delivery.
- D. Protect bark, branches, and root systems from sunscald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- E. Handle planting stock by root ball or container.
- F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F until planting.
- G. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
- H. If plants are stored for over 24 hours provide the following:
 - 1. Set balled stock upright on ground and cover ball with soil, peat moss, sawdust, or other acceptable material to prevent wind, cold, or heat damage to the roots.
 - 2. Provide shade to shade requiring trees and shrubs.

3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.8 PROJECT CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
 1. Notify Owner and Architect no fewer than two days in advance of proposed interruption of each service or utility.
 2. Do not proceed with interruption of services or utilities without Architect's written permission.
- C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 1. Spring Planting: February 15 – June 1.
 2. Fall Planting: October 15 – December 30.
- D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- E. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated or acceptable to Landscape Architect.
 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.
- F. Under no circumstances should work proceed prior to establishment of appropriate grades.
- G. Water Source:
 1. The Owner shall provide water for:
 - a. The construction period until Substantial Completion for the last phase of work.
 - b. Substantial Completion for the last phase of work through the maintenance period.

2. The Contractor shall provide watering labor as follows:
 - a. The construction period until Substantial Completion for the last phase of work.
 - b. Substantial Completion for the last phase of work through the maintenance period. Unusual Field Conditions: It is the Contractor's responsibility to communicate to the Architect unusual field conditions found at the project site before and during construction. The presence of unusual field conditions such as wind, wetness, soil issues, invasive weeds, will require the Contractor take note and advise the Architect on how best to remedy the discovery.

1.9 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling, blowing over or settling out of plumb.
 - c. Faulty performance of tree stabilization, edgings, or subdrainage.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 2. Warranty Periods from Date of Substantial Completion:
 - a. Trees, Shrubs, Ornamental Grasses, Ground Covers, and Other Plants, metal edges, decorative mulches, landscape drainage features, landscape grading: 12 months.
 3. Include the following remedial actions as a minimum:
 - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. There will be no limitation on replacements of each plant except for losses or replacements due to species intolerance of environmental conditions.
 - 1) Contractor shall notify Landscape Architect in writing of any concerns related to species intolerance of environmental conditions prior to purchase of plant material; otherwise, purchased plant material will be accepted by Contractor as tolerant of environmental conditions. Detrimental conditions shall be corrected prior to installation of plant material and shall not be considered grounds for warranty exclusion.
 - d. Provide extended warranty for period equal to original warranty period, for replaced plant material. As required, continue extended warranty until leaf

out to ensure health of replaced material. Plants shall be deemed dead if leaf out does not occur prior to end of spring.

4. All replacements shall be plants of the same kind as originally planted and shall be of size equal to that attained by adjacent plants of the same kind at the time replacement is made. They shall be furnished and planted as specified herein.
5. Removal and replacement shall be at no cost to the Owner.

1.10 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than Construction Maintenance Period below.
 1. Construction Maintenance Period: 12 months. The Construction Maintenance Period will begin from the date of Substantial Completion for the last phase of work. Partial areas of the site substantially completed require continued maintenance until all areas of the site are deemed substantially complete and until final date of Construction Maintenance Period.
- B. For Mechanized Tree Spade Trees: Provide 6 months of watering by refilling slow release water bags from the date of installation.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
 1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will be rejected.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 3. Provide trees from active, consistently aged specimens.
 4. Unless directly specified, provide only trees that are genetic clones of the requested variety.

- B. Select Balled and Burlapped material from nurseries who utilize root pruning practices and have a systematic approach to hardening off newly dug material.
- C. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- D. Provide small trees and shade trees that are grown on their own roots, not utilizing grafting or budding techniques (unless directed in the plant list).
- E. Provide container plant material that is free from circling roots or pot bound conditions.
- F. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- G. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.
- H. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Provide lime in form of ground dolomitic limestone.

2.3 ORGANIC SOIL AMENDMENTS

- A. Soil Conditioner: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 70 percent of dry weight.
 - 2. Sources: Agricultural, bark, biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
 - a. Free of toxic materials to plant growth
 - b. Free of weed seeds.

2.4 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.

- B. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory. Several different blends may be necessary to meet the requirements.

2.5 PLANTING SOILS

- A. Planting Soil Type B: Existing [found on site], native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth by mechanical screening.
 - 1. Screen native material to remove extraneous materials
 - 2. Supplement with approved Type C topsoil when quantities are insufficient.
 - 3. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of soil conditioner to Topsoil by Volume: 1:10.
 - b. Weight of Slow-Release Fertilizer as per soil test.
 - c. Weight of dolomitic limestone as per soil test.
- B. Planting Soil Type C: Imported sandy loam topsoil formed under natural conditions blended with organic matter. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - 1. Ratio of soil conditioner to Topsoil by Volume: 1:10.
 - 2. Weight of Slow-Release Fertilizer as per soil test
 - 3. Weight of dolomitic limestone as per soil test.
- C. Planting Soil Type D: 50/50 blend of sand and imported organic compost. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - 1. Ratio of soil conditioner to Topsoil by Volume: 1:10.
 - 2. Weight of Slow-Release Fertilizer as per soil test
 - 3. Weight of dolomitic limestone as per soil test.

2.6 MULCH

- A. Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 2 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Triple shredded hardwood or Pine straw; location for each type noted on drawings.
2. Color: Natural.

2.7 DECORATIVE STONE

- A. Hard, durable stone, washed free of fines, loam, sand, clay, and other foreign substances, of following type, size range, and color:

TYPE	SIZE	COLOR	DESCRIPTION
Rounded River Rock	1-3"	White, light beige, light gray	Rounded river rock
Decorative Gravel Paving	NCDOT #9	Dark gray, no pinks	Angular granite

2.8 METAL EDGING

- A. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
1. Edging Size: 1/4 inch wide by 5 inches deep.
 2. Stakes: Tapered steel, a minimum of 15 inches long; Provide 24 inch long stakes when recommended for installation in sand.
 3. Accessories: Standard tapered ends, corners, and splicers.
 4. Finish: Standard paint
 5. Paint Color: Black .

2.9 MISCELLANEOUS PRODUCTS

- A. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

2.10 HERBICIDES

- A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.11 PESTICIDES

- A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

- 1. Use pesticides on an as-needed basis.

2.12 TREE STABILIZATION MATERIALS

- A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood Stakes and Guys; to be used for canopy trees not planted in decorative gravel paving.

- 1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated, pointed at one end.
 - 2. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
 - 3. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
 - 4. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.

- B. Below Grade Root-Ball Stabilization Materials: Use for all trees within decorative gravel paving.

- 1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal by length indicated; stakes pointed at one end.
 - 2. Wood Screws: ASME B18.6.1.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.

- 1. Verify that subgrades are correct prior to spreading topsoil or spreading amendments.
 - 2. Conduct water percolation tests to verify that planting depths and drainage will meet the needs of the plants that have been selected. Inform the Architect of any drainage issues.

3. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
4. Along roadways and in landscape islands, remove gravel and asphalt from landscape beds.
5. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
6. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
7. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

1. For grade sensitive layouts, set up level lines and grade stakes to insure proper planting depths.
2. Contractor shall schedule meeting with owner and architect to stake all proposed tree locations on site and verify any conflicts with existing trees not surveyed prior to installation.

3.3 GENERAL REQUIREMENTS FOR ALL PLANTING TYPES

A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

- D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- E. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
 - 1. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
 - 2. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
 - 3. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
 - 4. Maintain supervision of excavations during working hours.
 - 5. Keep excavations covered or otherwise protected when unattended by Installer's personnel.
 - 6. If subdrainage is shown on Drawings or required under planting areas, insure contact between the root ball and subdrain pipe.
- F. After excavation examine the area for potential drainage difficulties matched to plant varieties and inform the Architect of potential poorly drained areas. Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits. Discuss variations in the depth of planting with the Architect prior to planting.
- G. Fill excavations with water and allow it to percolate away before positioning trees and shrubs.
- H. Set out and space plants according to the planting plans and notes in even rows with triangular spacing unless otherwise indicated.
- I. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.
- J. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- K. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- L. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- M. Backfill plants with the materials and methods indicated in the Tables below and with the following instructions:

1. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
3. Continue backfilling process. Water again after placing and tamping final layer of soil.

3.4 MASS PLANTING AREA REQUIREMENTS

- A. Preparation - Loosen subgrade of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 2

PLANT TYPE	TREATMENT AREA	SUBSOIL TREATMENT	EXCAVATION BACKFILL	PLANTING SOIL* DEPTH
Shrub and Ground-cover masses	entire planting area	Loosen 8" deep	Use Planting Soil B, C	6"

1. Spread planting soil to a depth indicated in Table 2 but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet. Mix planting soil with the subsoil to form an uneven soil horizon line.
2. Subsoil removed from excavations may not be used as planting soil.

3.5 SOLITARY TREES AND SHRUBS PLANTING REQUIREMENTS

- A. Preparation - Loosen area of planting areas to a minimum depth indicated in the table below. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

Table 4

	Treatment area	Subsoil treatment	Backfill from excavation	Planting Soil * depth in treatment area
Solitary Trees	10 wider than the	Loosen 12" deep	Use Planting Soil B, C	8"

	root ball			
Solitary Shrubs	10 wider than the root ball	Loosen 12" deep	Use Planting Soil B, C	6"

- B. Subsoil removed from excavations may not be used as planting soil.

3.6 MECHANIZED TREE SPADE PLANTING

- A. Supply trees as indicated in the plant list as harvested local trees.
- B. The Architect shall tag all trees to be locally harvested with tree spade techniques.
- C. Trees shall be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
- D. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
- E. Cut exposed roots cleanly during transplanting operations.
- F. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.
- G. Plant trees as shown on Drawings, with the following procedures :
1. Lower trees without damaging trunk or major branches
 2. Fit the root ball into the hole leaving a minimum of gap between the root ball and hole.
 3. Fill the remaining gap with a 70% sandy loam topsoil, 30% organic matter and fertilizer blend. Use water to carry mixture to the bottom of the excavation to insure the gap is full. Allow to drain and return the next day and repeat as necessary until all gaps are filled.
 4. Stake the tree with appropriate cabling systems and insure the tree is plumb.
 5. Mulch the tree planting area.
- H. Where possible, orient the tree in the same direction as in its original location.
- I. Supply one slow release watering bag per 4.5" caliper of tree.

3.7 PLANT STABILIZATION

- A. Install plant stabilization as follows unless otherwise indicated:

PLANT SIZE	STABILIZATION METHOD

6" in Caliper and Greater	Anchor 4 guys to wood deadmen buried at least 36 inches below grade. Provide turnbuckle and compression spring for each guy wire and tighten securely. Allow enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.
3" to 6" in Caliper	Anchor 3 guys to 30" wood stakes. Install guy wires allowing enough slack to avoid rigid restraint of tree. Provide soft flexible protection of the trunk from the guy wires. Attach flags to each guy wire, 30 inches above finish grade.

- B. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Refer to planting plan for location of plants to be receiving underground stabilization.
2. Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.8 PLANT PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Do not apply pruning paint to wounds.

3.9 EDGING INSTALLATION

- A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.
- B. Chiseled Edging: Construct chiseled edge separating mulch areas from lawn as shown in the drawings.

3.10 PLANTING AREA MULCHING

- A. Layout mulch beds carefully with smooth lines and as indicated on the drawings. Mulch backfilled surfaces of planting areas and other areas indicated.
- B. Organic Mulch in Planting Areas: Apply over whole surface of mass planting areas or on isolated plantings as follows:
1. Initial Mulch Application to New Planting Areas:
 - a. 2" minimum depth for trees, shrubs and groundcovers.
 - b. 1 ½" minimum depth for groundcovers, and perennial beds.
 2. Initial Mulch Application to Existing Planting Areas:

- a. Supplement mulch as needed to restore entire mulch profile to depths noted for initial mulch application to New Planting Areas.

C. Do not place mulch within 3 inches of tree or large shrub trunks.

3.11 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of weeds, insects and disease.
 1. Supplement mulch when entire mulch profile is 50 percent of depth required for initial mulch application to New Planting Areas. Restore entire mulch profile to depth indicated in these specifications.
- B. Until final acceptance fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- C. Include the following required action at end of Warranty Period:
 1. Remove tree staking systems, above and below grade.
 2. Remove tree saucers.
 3. Expose root crowns of all trees planted on the job.

3.12 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- C. After installation and before Substantial Completion remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.13 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 329300

SECTION 331413 – WATER DISTRIBUTION SYSTEM

NOTE: THE BELOW SPECIFICATIONS WERE DERIVED FROM CFPUA STANDARD SPECIFICATION SECTION 02660 – EFFECTIVE 5/12/16. ALTERATIONS TO THE CFPUA STANDARD SPECIFICATIONS HAS BEEN LIMITED TO SECTION NUMBERING AND SECTION REFERENCES FOR CONSISTENCY WITH OVERALL PROJECT DOCUMENTS.

PART 1 GENERAL

1.1 DESCRIPTION:

- A. This section gives the requirements for installation of water lines, including pipe, valves, and service connections and sampling stations. Excavation, trenching, and backfilling are covered in SECTION 312213: Excavation, Grading, Trenching and Backfilling.
- B. The foreman of the contracting crew must speak fluent English.
- C. Any event requiring a Cape Fear Public Utility Authority (CFPUA) representative to be present will require a 2 working day notice to schedule the event.
- D. No valves are to be operated unless a CFPUA representative is present. Any valves operated without a CFPUA representative present or a directive may be subject to penalties in accordance with CFPUA's Ordinance.

1.2 SUBMITTALS

- A. Test Reports: Submit all the results of the bacteriological tests to the CFPUA Engineering Inspector.
- B. Shop Drawings: Contractor shall furnish to CFPUA Engineering shop drawings and material specification sheets of all material and items to be installed or delivered as specified in Section 0133000: Submittal Procedures.

PART 2 PRODUCTS

2.1 PIPE

- 211 GENERAL:** Water main and service shall be constructed of PVC pipe except when ductile iron is required. Water service laterals shall be constructed of CTS PE tubing.
- 212 DUCTILE IRON PIPE** shall conform to ANSI/AWWA C150/A21.50, ANSI/AWWA C151/A21.51, Thickness Class 52, with minimum pressure ratings of 350 psi for 4"-12", 250 psi for 14"-20" and 200 psi for 24" and larger, with asphalt coating and cement mortar lining unless otherwise shown or specified.

- A. Joints shall be push-on or mechanical joints conforming to ANSI/AWWA C111/A21.11, with a minimum pressure rating of 350 psi or the specified pressure rating of the pipe, with a minimum safety factor of 2:1.
- B. Linings for pipe and fittings shall be standard thickness cement-mortar in accordance with ANSI/AWWA C104/A21.4.
- C. OUTSIDE COATING: The outside coating shall be a minimum of 1 mil bituminous paint according to ANSI/AWWA C151/A21.51.

213 POLYVINYL CHLORIDE (PVC) PIPE AND HIGH DENSITY POLYETHYLENE (HDPE) PIPE:

- A. HDPE MAINS: Pipe shall be 2-inch minimum, SDR 9, 200 psi, and will be used for directional drilling as directed by CFPWA.
- B. 2-INCH PVC MAINS: Pipe shall be ASTM D2241, IPS, Gasketed Pipe, SDR 21 minimum and shall bear the seal of NSF.
- C. 4-INCH – 12-INCH PVC MAINS: Pipe shall conform to requirements of AWWA C900 Class 150 (DR 18). Pipe shall bear the seal of NSF. Joints shall conform to ASTM D3139 or ASTM D3212.
- D. 14-INCH – 36-INCH PVC MAINS: Pipe shall conform to requirements of AWWA C905 Class 235 (DR18). Pipe shall bear the seal of NSF. Joints shall conform to ASTM D3139 or ASTM D3212.

214 FITTINGS AND SPECIALS

- A. Fittings and specials shall be Thickness Class 52 ductile iron, mechanical joint in accordance with ANSI/AWWA C111/A21.11, ANSI/AWWA C153/A21.53, 150 pounds per square inch pressure rating unless otherwise shown or specified, except that profile of bell may have special dimensions as required by the pipe manufacturer with elastomeric gaskets. Ductile iron fittings and specials shall be cement-mortar lined (standard thickness) in accordance with ANSI/AWWA C104/A21.4. Fittings shall be for bell and spigot pipe.
- B. Buried service fittings and specials shall be suitable for 350 psi working pressure for 4"-24" and 250 psi pressure rating for 30"-64", minimum, unless otherwise specified. Fittings and specials for mechanical joint pipe shall conform to C153/A21.53.
- C. Aboveground service fittings (valve vaults, valve pits, pump stations, etc.) shall be rated for 250 psi working pressure for sizes 4"-64".

215 SERVICE LINE PIPING

Pipe shall be polyethylene (PE) tubing, SDR 9, 200 psi, conforming to ASTM D2737/AWWA C901. No joint shall be installed between the main service tap and

the meter stop. In proven contaminated soil conditions, copper (Type K) services may be required at the discretion of CFPUA.

216 MECHANICAL JOINT RESTRAINT GLAND:

- A. No mild carbon steel fasteners, bolts (i.e., ASTM A307), or harnessing shall be permitted for underground service on water system components. All fasteners, bolts, and harnessing shall be stamped 316 stainless steel.
- B. Mechanical joint restraint shall be incorporated in the design of the follower gland and shall include a restraining mechanism which, when actuated, imparts multiple wedging action against the pipe, increasing its resistance as the pressure increases. Flexibility of the joint shall be maintained after burial.
- C. Glands shall be manufactured of ductile iron conforming to ASTM A536-80. Restraining devices shall be of ductile iron heat treated to a minimum hardness of 370 BHN. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee-head bolts conforming to ANSI/AWWA C111/A21.11 and ANSI/AWWA C153/A21.53 of latest revision. Twist-off/Torque nuts shall be used to insure proper actuating of the restraining devices.
- D. Restraint glands shall be "Megalug" with Megabond as manufactured by EBAA Iron, Inc., or "Camlock" with Flexi-Coat as manufactured by Smith-Blair, Inc., "Stargrip" with Starbond, as manufactured by Star Pipe, or equal. .

217 Rodding could be situation specific (with 316 stainless steel rods and nuts).

218 PACKING MATERIALS AND JOINTS

No contaminated material or any material capable of supporting prolific growth of micro-organisms shall be used for sealing joints. The lubricant used in the installation of sealing gaskets shall be suitable for use in potable water and shall conform to AWWA C111/A21-11. It shall be delivered to the job in enclosed containers and shall be kept clean. If proven contaminated soil conditions exist, Nitrile or Neoprene Gaskets may be required by the sole discretion of the CFPUA Engineering Representative.

219 If 316 stainless steel is not available, submit alternate for CFPUA approval.

2.2 VALVES

221 VALVES: Iron body, bronze mounted, double disc, parallel seat type meeting the full requirements of AWWA C500, or resilient seated valves in conformance with AWWA C509 or C515. Valves larger than 16-inches shall be fully-ported gate valves and require side gear box if cover is not sufficient. Valves shall have 2-inch operating nut and open left, and shall have O-ring seals. Valve ends shall be mechanical joint, unless otherwise shown or specified. The valve bonnet shall have 316 stainless steel fasteners. The coating on the valve shall conform to AWWA C550 and ANSI/NSF 61. Valves

shall be manufactured by Mueller, American Darling or Clow Corporation or approved equal.

222 VALVE BOXES: Square nut valve boxes shall be cast iron screw adjustment type with flared base. The word "WATER" shall be cast in the cover. The boxes shall be of such length as will be adapted, without full extension, to the depth of cover required over the pipe at the valve location. Boxes shall be installed over each gate valve, unless otherwise shown or specified. Valve boxes shall conform to ASTM A48 "Grey Iron Castings" Class 30B or approved equal.

223 VALVE BOX CONCRETE COLLARS: Valve boxes in unpaved areas shall be installed with either pre-cast or poured in place concrete collars.

2.3 FIRE HYDRANTS: Hydrant valves shall open left. Hydrants shall be iron body, fully bronze mounted, dry barrel type with breakaway flange and stem coupling conforming to AWWA C502, with valve opening not less than 4.5-inches in diameter. Hydrants shall have a 6-inch mechanical joint connection on the inlet end. Outlets shall have 5" STORZ and 2-1/2" American National Standard fire hose coupling threads. Working parts shall be bronze. Hydrants shall be Mueller, American Darling, Clow or approved equal.

2.4 WATER SAMPLING STATIONS: Sampling stations shall be installed on all 2-inch or larger services and mains or as directed by CFPUA. The sampling station shall be installed immediately upstream of the reverse backflow preventer or as directed by CFPUA. The sampling station shall be the Eclipse No. 88 model by the Kupferle Foundry Company, or approved equal, and will be installed per CFPUA Specifications. A ground collar shall be placed around the sampling station and embedded to a minimum depth of 6-inches and the annular space between the ring and sampling station shall be filled with washed stone, #57 or equivalent.

2.5 SERVICE LINE ITEMS

251 SERVICE TAPS – 1 INCH

A. **SERVICE SADDLES:** Saddles for PVC main shall be wide band brass body service saddles, McDonald 3801 series, Mueller H 13000 series, or approved equal. Saddles for ductile iron pipe shall be Smith Blair Model 313 or approved equal, hardware shall be 316 stainless steel. Size of tap shall match that of the service line (1-inch minimum tap).

B. **CORPORATION STOP:** Connection stop shall have compression nut and gasket service line connections. Size of corporation stop shall match that of service line. Corporation stop shall be McDonald Model 4701B-22, Mueller Model P-15008, or approved equal. Stainless steel insert stiffeners, 1-inch diameter, McDonald Part Number 6133T or approved equal shall be used on all compression fittings.

C. **THREADS:** shall be corporation cock threads.

252 SERVICE TAPS – 2-INCH

- A. SERVICE SADDLES: Saddles for PVC mains shall be wide band, 2 pieces, brass body (McDonald 3801 Series) Ford S90 (double strap) or bronze body (Mueller Series H-13000). No three piece service saddles are permitted.
- B. TAPPING SLEEVE/VALVE: The tapping valve shall be a 2-inch, Resilient Wedge Gate Valve, AFC 2502 SS or approved equal.
- C. VALVE BOXES: A valve box as specified in the specifications shall be installed with the 2-inch tapping valve and larger.

253 SINGLE SERVICE LINE

- A. COMPRESSION ADAPTER FITTINGS: Service stops shall have compression adapter fitting for connection to 1-inch diameter (minimum) PE water service line and shall be McDonald Model 4753-22 or approved equal. Stainless steel insert stiffeners, 1-inch diameter, McDonald Part Number 6133T or approved equal shall be used on all compression fittings.
- B. SERVICE ANGLE STOPS: Service stop shall have threaded fitting for connection to compression adapter and shall be McDonald Model 4642B, or approved equal.

254 DUAL SERVICE LINE

- A. U-BRANCH FITTING: Dual service connections shall be split using a U-branch fitting with compression fittings for connection to a 1-inch diameter PE service line. Branch shall be McDonald 08U2M with 71/2" spread, Mueller Model H-15365, or approved equal with 3/4-inch threaded connection for service stop. Stainless steel insert stiffeners, 1-inch diameter, McDonald Part Number 6133T or approved equal shall be used on all compression fittings.
- B. SERVICE ANGLE STOPS: Service stop shall have threaded fitting for connection to U-branch and shall be McDonald Model 4604B, or approved equal.

255 LARGE METER SETS AND STRAINERS

- A. 1-½ inch and 2-inch meters shall be set in a McDonald Meter Setter, Series 775, sized per meter service size, Ford VBB77-15B-11-77 or approved equal.
- B. 3-inch and larger water meters shall have a separately mounted strainer basket assembly for trapping and removal of large particles, and a lockable bypass per Standard Detail.

- 256 WATER METER BOXES:** Boxes shall be cast iron or plastic with cover complete with lifting lug and a metal read lid. Water meter boxes are to be a minimum of five (5) feet from the property corner.

- A. Single meter box shall be Carson 1015-12 Black Meter Box with 2/6 MSHI F with cast iron reader or approved equal.
- B. Double meter boxes shall be Carson 1220-12 Black Meter Box with 2/6 MSHI F with cast iron reader or approved equal.
- C. Cast iron boxes conforming to ASTM A48, Class 30B, meeting H20 Loading Standards, shall be used in traffic areas. The box shall be a SIP model 4242 with model 4243 lid.
- D. Large meter boxes for 1-1/2" or 2" meters shall be Sigma MB 2203 large cast iron boxes (minimum 26-3/4" x 6-3/4").

257 WATER METER VAULTS:

- A. Locate meter vaults outside of pedestrian and vehicle traffic areas.
- B. Water meter vaults shall be constructed of pre-cast concrete and sized to provide sufficient access for maintenance and protection of the meter and enclosed valves. The base of the vault shall be placed on 6" thick layer of #57 stone. The top of the meter vault shall be set 6-inches above grade.
- C. The meter vault lid shall be single leaf lockable with matching eye and padlock, rain tight aluminum hatch of size and dimension as shown on drawings. At a minimum, the lid must be sized to allow unrestricted maintenance access for meter retrieval and reset. Hatches shall be manufactured by Halliday Products, Inc. or approved equal. Valves and meters within the vault shall be adequately supported to counteract their weight and all imposed dynamic loads. All water main piping within a minimum of 5' of vault shall be restrained joint ductile iron.
- D. If remote read is being used, the remote read head shall be mounted flush to the aluminum top and adjacent to the hinge so that the meter can be read with CFPUA equipment without opening the vault. Electronic wiring between the meter and the door mounted electronic remote read head shall have proper slack, be in a protective sheath, secured, and installed adjacent to the hinge to minimize entanglement and interference with door opening and maintenance access.

258 SERVICE INTENDED FOR FIRE PROTECTION:

- A. CFPUA provides potable water service which may be interrupted for repairs, system expansion, or other general requirements. CFPUA does not guarantee adequate fire flow for protection of life or property. There shall be no domestic use taps allowed on a dedicated fire line. Some facility owners choose to utilize this interruptible potable water supply from the CFPUA system for fire protection. If facility owners choose to utilize the potable water system for fire protection flow, the service for fire protection shall be configured in one of two methods:
- B. Two taps shall be installed, one for potable water and one for fire flow. The

potable water tap shall be installed and metered in accordance with Section 2.05 SERVICE LINE ITEMS. All meters installed on lines greater than 2-inch diameter must have a strainer and be installed in an appropriately sized, approved meter vault that provides sufficient access for reading, maintenance, and protection in accordance with Water Meter Vaults specification.

- C. The fire flow tap shall not be metered and the fire flow system shall be fully segregated from the potable system throughout the facility. A valve will be installed at the tap and the right-of-way or easement line denoting the CFPUA owned/privately owned boundary. A privately owned, privately maintained reduce pressure zone (RPZ) backflow prevention device shall be installed in the line immediately after entering a structure in accordance with the North Carolina State Building Code and the CFPUA Cross Connection Control Ordinance.

2.6 PIPE LOCATION WIRE:

Pipe locator wire shall be installed on all main lines, hydrant legs and services as per specifications. A 10 gauge insulated copper wire rated for underground waterproof application. All splices in the wire shall be made with 3M DBR Direct Bury Splice Kit an underground rated, watertight, and approved splice connector or approved equal.

PART 3 EXECUTION

- 3.1 **GENERAL:** Install pipe in strict conformance with AWWA C600. Minimum depth of bury above the top of pipe shall be 36 inches unless ductile iron pipe is used. Install plastic pipe in conformance with ASTM D2774 and recommended practices of the UNI-BELL Plastic Pipe Association (www.uni-bell.org)
- 3.2 **CUTTING OF PIPE:** Cut pipe in a neat and workmanlike manner without damage to the pipe or its lining.
- 3.3 **ADJACENT FACILITIES:** Refer to specification for Gravity Sanitary Sewer for adjacent facility locations.
- 3.4 **JOINT DEFLECTION:** Maximum joint deflection shall meet requirements of AWWA C600 or AWWA Manual of Practice M23.
- 3.5 **PIPE LOCATOR WIRE:** The locator wire shall be run continuously along the pipe and shall be securely taped to the top of the water line and all service laterals. The locator wire shall not be wrapped around the pipe, flanges, bells, valves, or other appurtenances. The locator wire shall be accessible above ground at one thousand feet (1,000') intervals and shall be protected by a cast iron box with cover marked "water" with a concrete collar. At valve boxes, the wire shall be brought up on the outside of the box, a hole is to be drilled with a grommet near the top of the valve box for wire to be taped to the inside of the box for protection. At valve boxes, the wire shall be brought up on the outside of the box, a hole is to be drilled with a grommet near the top of the valve box for wire to be taped to the inside of the box for protection. The contractor is required to verify and certify the continuity of the locator wire in the presence of the CFPUA Inspector before the line is accepted by CFPUA

using low frequency line tracing equipment.

3.6 JOINTING OF PIPE

- 3.6.1 KEEPING PIPE CLEAN AND DRY:** Precautions shall be taken to protect pipe interiors, fittings and valves against contamination. Pipe delivered for construction shall be strung so as to minimize entrance of foreign material. When pipe laying is not in progress, for example, at the close of the day's work, all openings in the pipeline shall be closed by water-tight plugs. Joints of all pipe in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is dry. It is recommended that only the amount of pipe to be installed that day be strung out.

Note: Delay in placement of delivered pipe invites contamination. The more closely the rate of delivery is correlated to the rate of pipe laying, the less this delay. If the dirt will not be removed by the flushing operation in the opinion of the Owner's Engineer, the interior of the pipe shall be cleaned and swabbed as necessary, with a five (5%) percent hypochlorite disinfecting solution @ 300 mg/L residual.

- 3.6.2 DUCTILE-IRON PIPE** shall be installed in accordance with AWWA C600, modified as necessary by the recommendations of the manufacturer.
- 3.6.3 PVC PIPE** shall be installed in accordance with AWWA Manual of Practice M23, modified as necessary by the recommendations of the manufacturer.
- 3.6.4 CONNECTIONS** between different types of pipe and accessories shall be made with transition fittings approved by CFPUA's Representative.
- 3.6.5 SERVICE LATERALS:** Service laterals shall consist of a tapping saddle, corporation stop and a length of PE pipe with no joint installed between the main service tap and the service stop. Service laterals shall be installed perpendicular to the water main. Contractor shall install all material per the detail allowing for meter installation at a later date by CFPUA personnel. Locator wire shall be installed as per specifications.

3.7 SETTING OF VALVES, VALVE BOXES AND FIRE HYDRANTS

- 3.7.1 GENERAL:** Install where shown or directed and set plumb on a brick foundation. Valve boxes shall be centered on the valves. Boxes shall be installed over each outside gate valve. Where feasible, valves shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face if less than 4 feet.
- 3.7.2 VALVES** after delivery shall be drained to prevent freezing and shall have the interiors cleaned of all foreign matter before installation. Valves shall be fully opened and fully closed to insure that all parts are in working condition.

3.8 RESTRAINING AND BLOCKING

The plugs, caps, tees and bends deflecting 11 1/4 degrees or more either vertically or horizontally on water lines 6 inches in diameter or larger shall be provided with thrust blocking or "Megalug" or Camlok retainer gland at each joint, installed per manufacturer's requirements. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust blocks shall be poured directly against undisturbed earth, with a blocking cure time of 5 days. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown on the plans or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Rods and clamps shall be 316 stainless steel.

3.9 FIRE HYDRANTS

Locate and install as shown on the drawings. Each hydrant shall be connected to the main with a 6-inch branch line. Hydrants shall be set plumb with the pumper nozzle facing the roadway and with the center of the lowest outlet not less than 18 inches above the finished surrounding grade and the operating nut not more than 48 inches above the finished surrounding grade. The hydrant shall be set in a bed of crushed rock which shall surround the barrel at least 12 inches in all directions. Hydrants shall be restrained with 316 stainless steel tie rods extending from the main line tee to the hydrant, or by combination of tie rods and blocking or by "Megalug" retainer glands at each joint per manufacturer's requirements. Hydrant valves shall be located at the main as close to the tee or tap as possible, 18" maximum.

3.10 HYDROSTATIC TESTING

3.10.1 GENERAL: After all water mains and appurtenances are installed and where any section of a water line is provided with concrete thrust blocking, the hydrostatic test shall not be made until at least 5 days after installation of the concrete thrust blocking unless otherwise approved. The method proposed for disposal of wastewater from hydrostatic tests and disinfection shall be submitted to the Owner's representative prior to performing hydrostatic tests. Use clean potable water for all testing of lines. The contractor is to contact the CFPWA representative to schedule the observation of any valves to be operated for flushing and pre-testing.

3.10.2 PRESSURE TEST

- A. For purposes of testing, working pressure shall be 100 psi and test pressure shall be 150 psi. Air testing will not be accepted on mains and services, (Only Hydrostatic Testing is allowed), but will be accepted for saddles, 40 psi for 15 minutes. The pressure gauge must be liquid filled with 2 psi increments maximum. The gauge must be a minimum of three feet above grade. No more than 3 psi can be lost during the two hour test. The gauge must return to 0 psi when the test is completed.
- B. Pressure test in strict conformance with AWWA C600, Section 4.1 and 4.2. Test for leakage concurrent with the CFPWA requirements for the

pressure test or in conformance with AWWA C600, Section 4.2, Table 6, which shows allowable leakage per 1000 ft. of pipeline allowed. Remedy all visible leaks and locate and repair leakage in lines which exceed the specified amounts.

- C. The contractor is to contact the CFPWA representative with a 48 hour notice, to schedule the observation of any test. The contractor will pre-test the lines prior to the CFPWA representative arrival. The contractor is to cancel the test if the lines will not pass the required test and remedy all visible leaks and locate and repair leakage in lines which exceed the specified amounts. When completed, the contractor will re-schedule the test.

3.11 DISINFECTION

3.11.1 DISINFECTING WATER MAINS, FIRELINES AND 4" OR LARGER SERVICES

- A. Each unit of constructed water main shall be disinfected with chlorine upon successful completion of the hydrostatic test. The disinfection procedure shall be performed in strict conformance with CFPWA Procedures for Disinfecting Water Mains, as outlined below.
- B. The Contractor shall pay particular attention to the scheduling requirements outlined in the procedures. The Contractor shall be responsible for furnishing and installing all required chlorine injection and monitoring ports at no additional cost to CFPWA.
- C. The mains will in no case be accepted by CFPWA for public use until the CFPWA Engineer approves the mains as having been properly disinfected.

3.11.2 PROCEDURES FOR DISINFECTING WATER MAINS

A. GENERAL INTENT

It is the intent of these procedures to present essential steps for disinfecting new and repaired water mains. All steps must be initiated and complied with in order for permission to be given for these water lines to be opened for use by CFPWA water customers. Pressure testing must be completed and approved before chlorination procedures are started

B. BASIC PROCEDURES

The basic procedure comprises:

1. Preventing contaminated materials from entering the water mains during construction or repair and removing by flushing materials that may have entered the water main.
2. Disinfecting any residual contamination that may remain.
3. Determining the bacteriological quality by laboratory test after disinfection.

C. STANDARD OF REFERENCE

All procedures herein shall comply with the AWWA Standard C651-92 for Disinfection of Water Mains or the latest revision.

D. CHLORINATION PLANNING

The planning process prior to chlorination involves checking the design plan for the correct installations and layout needed for chlorination, routing, the chlorine solution and numbering blowoff sample points, calculating the required amount of chlorine, and determining the required amount of time to properly chlorinate the system. Planning is necessary to ensure that newly installed pipes are chlorinated properly and safely.

Before calling the CFPUA office for a time to be set up for disinfection, all of the following must be installed or supplied by the Contractor at no cost to CFPUA. Also, this list should be checked and/or assembled before Engineering personnel arrive.

1. The line or lines to be disinfected should be connected to the CFPUA water system (main). A valve should be installed in the line to be disinfected near the CFPUA water main connection.
2. A blowoff of an approved material, or brass faucet should be installed at the dead end of the line and every 1,200 feet to be disinfected for flushing purposes and bacteria sampling. The opening to this blowoff should point downward, and there should be at least twenty-four inches clearance between the opening and the ground for proper sampling.
3. Copper or PVC blowoffs should be at all closed valves.
4. Mains connecting other mains with open valves within the system to be disinfected may cause "short circuits" resulting in improper disinfection. Valves on these connecting mains should be checked to see if they should be closed to eliminate this problem. Copper blowoffs should be at both sides of valves closed to prevent "short circuits".
5. The pressure test of the line needs to pass before attempting disinfection procedures.
6. A clean container is necessary to mix and/or dissolve the hypochlorite.
7. A clean, new wooden mixer should be present for mixing and dissolving the hypochlorite.
8. A pump for pumping the chlorine solution into the line should be present. This pump should be gasoline or electrically powered chemical feed pump designed for feeding chlorine solutions. For small applications, the solutions may be fed with a hand pump; for example, a hydraulic test pump. Feed lines shall be of such material and strength as to withstand safely the maximum pressures that may be created by the pumps. All connections shall be checked for tightness before the hypochlorite solution is applied to the main.

9. All temporary blowoffs and injection points shall be properly abandoned and physically disconnected when directed by CFPUA prior to the line being placed into service.
10. FORMS OF CHLORINE TO BE USED - The forms of chlorine that are to be used for the purpose of disinfection operation or water main repairs are sodium hypochlorite solution or calcium hypochlorite granules, conform to ANSI/AWWA B300.

E. PRELIMINARY FLUSHING

Flushing is the process of flowing water through a pipe to remove foreign particles which could cause contamination or blockage within the water system. All mains should be flushed prior to chlorination. The minimum amount of water required to flush a main is 1 ½ times the capacity of the main (capacity and time may be calculated using the chart below). A minimum velocity of 2.5 feet per second, but preferably 3.5 feet per second, should be maintained within the pipe to ensure that it is properly scoured. No site for flushing should be chosen unless it has been determined that drainage is adequate for this site.

<u>Diameter of Line (Inches)</u>	<u># Gal/Ft</u>
16	10.50
12	5.87
8	2.62
6	1.47
2	0.16

Multiply the # gal/ft for the size line by the length of line in feet. This will give you the number of gallons the pipe will hold.

NOTE: Flushing is no substitute for preventative measures taken before and during pipe laying. Certain contaminants, especially in caked deposits, resist flushing at any velocity. Furthermore, with diameters of 16 inches, even the minimum recommended flushing velocity of 2.5 feet/second is sometimes difficult to achieve.

Temporary blowoffs are a means of releasing water from a main for flushing. They are normally placed at "dead ends" and at each side of closed valves. A blowoff usually consists of a corporation stop, a length of pipe, and a curb stop at ground level; however, a blowoff on a large water main may consist of a gate valve and a length of pipe. Blowoffs are to be installed by the contractor installing the new water main. All permanent blowoffs shall be installed in accordance with standard details and specifications.

3.11.3 DISINFECTION PROCEDURES AFTER CUTTING INTO OR REPAIRING EXISTING MAINS

The following procedures apply primarily when mains are wholly or partially dewatered. After the appropriate repair procedures have been completed, the existing main may be returned to service prior to completion of the bacteriological testing to minimize the time customers are out of water. Leaks or breaks that are repaired with clamping devices while the mains remain full of water under pressure present little danger of contamination and require no disinfection.

A. MAIN DISINFECTION

1. Swabbing, Flushing and Sampling. The following procedure is considered as a minimum that may be used.
 - a. SWABBING WITH HYPOCHLORITE SOLUTION. The interior of all pipe and fittings used in making repair (particularly couplings and tapping sleeves) shall be swabbed with a five (5) percent hypochlorite solution (300 mg/l concentration) before they are installed.
 - b. FLUSHING. Thorough flushing is the most practical means of removing contamination introduced during repairs. If valve and hydrant locations permit, flushing toward the work location from both directions independently is recommended. Flushing shall be started as soon as the repairs are completed and shall be continued until discolored water and particulate matter are eliminated.
 - c. SLUG CHLORINATION: When practical, in addition to the procedures above, the section of main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated with a high concentration of chlorine (as much as 300 mg/L), and the concentration allowed to stay in contact with the main for a minimum of 15 minutes. After chlorination, flushing shall be resumed and continued until discolored water is eliminated and the water is free of noticeable high chlorine odor. A chlorine residual of no greater than 3.0 mg/L shall be acceptable.
 - c. SAMPLING. Bacteriological samples shall be taken after repairs are completed to provide a record for determining the procedures effectiveness. If the direction of flow is known, sample locations shall be determined. If the direction of flow is unknown, then samples shall be taken on each side of the main break. If bacteriological samples are unacceptable, the CFPUA representative will determine corrective action. Daily sampling shall be continued until two successive daily samples are acceptable.

3.11.4 SPECIFICATIONS FOR DISINFECTION OF WATER DISTRIBUTION MAINS

A. GENERAL

1. SCOPE: This standard presents essential procedures for disinfecting new and repaired water mains. All new water mains shall be disinfected before they are placed in service. All water mains taken out of service for inspection, repair, or other activities shall be disinfected before they are returned to service.
2. REFERENCES: This standard references the following documents. The latest current edition of each forms a part of this standard where and to the extent specified herein. In case of any conflict, the requirements of this standard shall prevail.

ANSI/AWWA C651 - 14	Disinfecting Water Mains
ANSI/AWWA B300	Standard for Hypochlorites
AWWA Manual - M3	Safety Practices for Water Utilities
AWWA Manual - M20	Water Chlorination Principles and Practices
AWWA Manual - M12	<i>Simplified Procedures for Water Examination</i>
APHA, AWWA, WEF	<i>Standard Methods for the Examination of Water and Wastewater</i>

3. RECORDS OF COMPLIANCE: The records of compliance shall be the following:
 - Coliform Bacteria:** Zero coliforms per 100 ml sample
 - Chlorine Residual:** Chlorine residual equivalent to the source water concentration

B. BASIC DISINFECTION PROCEDURES

The basic disinfection procedure consists of:

1. Preventing contaminating materials from entering the water main during storage, construction, or repair.
2. Removing by flushing or other means, those materials that may have entered the water main.
3. Chlorinating any residual contamination that may remain, and flushing the chlorinated water from the main.
4. Protecting the existing distribution system from backflow due to hydrostatic pressure test and disinfection procedures.
5. Determining the bacteriological and other related quality by laboratory testing after disinfection.
6. Final connection of the approved new water main to the active distribution system.

C. PREVENTIVE AND CORRECTIVE MEASURES DURING CONSTRUCTION

Heavy particulates generally contain bacteria and prevent even very high chlorine concentrations from contacting and killing such organisms. It is, therefore, essential that the procedures of this section be observed to assure that a water main and its appurtenances are thoroughly clean for the final disinfection by chlorination. Also, any connection of a new water main to the active distribution system prior to receipt of satisfactory samples may constitute a cross-connection. Therefore, the new main must be isolated until all bacteriological and other tests are satisfactorily completed.

1. **KEEPING PIPE CLEAN AND DRY:** Precautions shall be taken to protect the interiors of pipes, fittings, and valves against contamination. Pipe delivered for construction shall be strung so as to minimize the entrance of foreign material. All openings in the pipeline shall be closed with watertight plugs when work is stopped at the end of the day or for other reasons.
2. **JOINTS:** Joints of all pipes in the trench shall be completed before work is stopped. If water accumulates in the trench, the plugs shall remain in place until the trench is dry.
3. **PACKING MATERIAL:** All packing material shall consist of molded or tubular rubber rings, or other approved material. Lead or asbestos material in any form shall not be permitted.
4. **SEALING MATERIALS:** No contaminated material or any material capable of supporting prolific growth of microorganisms shall be used for sealing or lubricating joints. Sealing and lubricating material or gaskets shall be handled in a manner that avoids contamination. The lubricant used in the installation of sealing gaskets shall be suitable for use in potable water. It shall be delivered to the job in closed containers and shall be kept clean. Soil conditions could warrant the upgrade of gasket material to a volatile resistant material.
5. **CLEANING OF PIPE AND APPURTENANCES:** If dirt enters the pipe, it shall be removed and the interior pipe surface cleaned. If, in the opinion of the CFPUA representative, the dirt remaining in the pipe will not be removed by the flushing operation, then the interior shall be cleaned by mechanical means such as a hydraulically propelled foam pig or other suitable device. The cleaning method used shall not force mud or debris into the interior pipe joint spaces and shall be acceptable to CFPUA.
6. **FLOODING BY STORM OR ACCIDENT DURING CONSTRUCTION:** If the main is flooded during construction, it shall be cleared of the floodwater by draining and flushing with potable water until the main is clean. The section of pipeline shall be flushed until water from the pipe runs clear.

D. METHOD OF CHLORINATION

The contractor shall use the continuous feed method for disinfection of all new water mains. This method must give a minimum of 10 mg/L of chlorine residual at the end of the 24-hr period.

1. CONTINUOUS-FEED METHOD: The continuous-feed method is the process in which a concentrated solution of chlorine is injected into the water main. Caution shall be observed during the handling and injection of the chlorine solution as chlorine in any form is very toxic and any error could be harmful to the employees and to the public.
2. PRELIMINARY FLUSHING: Prior to any disinfection procedures being performed, all hydrostatic tests shall have been completed and accepted by the CFPUA representative. Before chlorine solutions are injected, the main shall be filled with potable water to eliminate air pockets and shall be flushed to remove particulates. The flushing velocity in the main shall not be less than 2.5 ft/sec (preferably 3.5 ft/sec) unless the CFPUA representative determines that conditions do not permit the required flow or that the flow will cause undue problems when discharged to waste. An acceptable flushing velocity shall then be determined and used.
3. PROCEDURE FOR CHLORINATING THE MAIN
 - a. Water supplied from the existing distribution system or other approved public water supply shall be made to flow at a constant, measured rate into the newly installed water main. In the absence of a meter, the rate may be approximated as best can be determined.
 - b. At a point not more than 10 ft downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 50 mg/L and not greater than 100 mg/L free chlorine residual. To ensure that this concentration is provided, measure the chlorine concentration at regular intervals of distance and time in accordance with the procedures described in the current edition of *Standard Methods for the Examination of Water and Wastewater* or AWWA Manual M12, or by using appropriate chlorine test kits (see appendix B).
 - c. During the application of the chlorine, valves shall be adjusted by or under the supervision of the CFPUA representative to prevent the chlorine solution from flowing back into the existing water system. The chlorine injection shall not cease until the entire water main is filled with a chlorine concentration of not less than 50 mg/L. All appurtenances and valves shall be operated to ensure that the chlorine solution has contact with them. The chlorinated water shall be allowed to remain for a period of not less than 24-hours.
 - d. At the end of the 24-hour period, the chlorine residual shall be measured and shall not be less than 10 mg/L in any samples

collected along the water main and at the end of said water main.

E. FINAL FLUSHING

1. CLEARING THE MAIN OF HIGHLY CHLORINATED WATER: Highly chlorinated water should not remain in prolonged contact with pipe. At the end of the 24-hour contact period, the water should be removed in order to prevent damage to the pipe lining or corrosion damage to the pipe itself. The highly chlorinated water shall be flushed from the main until chlorine measurements show that the concentration in the water leaving the main is no higher than that generally prevailing in the distribution system.
2. DISPOSING OF HIGHLY CHLORINATED WATER: A neutralizing chemical shall be applied to the chlorinated water to be discharged to neutralize thoroughly the chlorine residual remaining in the water (see appendix B). Where necessary, federal, state, and local regulatory agencies should be contacted to determine special provisions for the disposal of the neutralized water.

F. BACTERIOLOGICAL AND OTHER TESTS

1. STANDARD CONDITIONS: After final flushing and before the new main is opened to the distribution system, two consecutive sets of acceptable samples, taken at least 24-hours apart, shall be collected from the new main. Samples shall be collected from every 1200-ft of new water main, from the end of the water line, and from each branch. All samples shall be tested in accordance with *Standard Methods for the Examination of Water and Wastewater*. All samples shall show the absence of coliform organisms, and a free chlorine residual equal to the level present in the existing system and shall have no visible color or particulate matter. **Must be submitted in the form of an official report by a certified lab.**
2. SPECIAL CONDITIONS: If in the opinion of CFPUA, excess contamination has been allowed to enter the water main during construction or other events, bacteriological samples shall be taken at intervals of approximately 400 to 500 ft and shall be identified by location. Samples shall be taken of water that has stood in the new main for at least 16 hours after final flushing has been completed.
3. SAMPLING PROCEDURES: A copper or PVC assembly or a combination blowoff and sampling tap may be used for mains up to 8-inches diameter. Fire hydrants may not be used for sampling purposes. After samples have been collected, analyzed, and accepted, the sampling assemblies may be removed and retained for future use. All bacteriological analysis must be completed by a N.C. certified Drinking Water laboratory. The utility contractor shall be responsible for all costs associated with the sampling and analysis of all samples required for acceptance. **All Lab Reports shall be delivered to the CFPUA Representative before any activation can proceed.**

G. REPEAT DISINFECTION OF WATER MAIN

If the initial disinfection fails twice to produce satisfactory results as per specifications, the new main shall be reflushed, rechlorinated and resampled; CFPWA may also require further cleaning methods (i.e. pigging the line) if the disinfections fails twice. If check samples also fail to produce acceptable results, the new main shall be reflushed and rechlorinated by the continuous-feed method of chlorination until satisfactory results are obtained.

NOTE: High velocities in the existing system, resulting from flushing the new main may disturb sediment that has accumulated in the existing mains. When check samples are taken, it is advisable to also sample water entering the new main.

H. CONNECTION TO EXISTING SYSTEM

The NCPWS certifications, final acceptance, opening of valves and activation of the existing water system will only be allowed after satisfactory samples and chlorine levels have been produced. All sampling devices and blowoffs must be removed from the water main by the contractor prior to acceptance by CFPWA. The CFPWA Operations Department will activate the system when their procedures are completed.

I. CHLORINE RESIDUAL TESTING

Several manufacturers produce high-range and low-range chlorine test kits that are inexpensive, easy to use, and satisfactory for the precision required. Before line is flushed, but after 24 hours, a minimum of 10 mg/L of free Chlorine, Cl_2 , must reside in the line. The test kits should use methodology conforming with *Standard Methods for the Examination of Water and Wastewater* or AWWA Manual M12. Examples of such manufacturers include:

- Hach Company
- LaMotte
- Fisher Scientific
- Hellige

J. DISPOSAL OF HIGHLY CHLORINATED WATER

Chlorine residual of water being disposed will be neutralized by treating with one of the chemicals listed below:

- Ascorbic Acid
- Sulfur Dioxide
- Sodium Bisulfate
- Sodium Sulfite
- Sodium Thiosulfate

END OF SECTION 331413

SECTION 333111 - GRAVITY SANITARY SEWER SYSTEM

NOTE: THE BELOW SPECIFICATIONS WERE DERIVED FROM CFPUA STANDARD SPECIFICATION SECTION 02731 – REVISED 10/11/10. ALTERATIONS TO THE CFPUA STANDARD SPECIFICATIONS HAS BEEN LIMITED TO SECTION NUMBERING AND SECTION REFERENCES FOR CONSISTENCY WITH OVERALL PROJECT DOCUMENTS.

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section gives the requirements for installation of gravity sewer pipe, service laterals and manholes. Service laterals shall be installed where shown on the approved drawings or as directed by CFPUA Engineering staff. Excavation, trenching and back filling is covered in Section 312213: "Excavating, Grading, Trenching, and Backfilling".
- B. The foreman of the contracting crew must speak fluent English.

1.2 SUBMITTALS

- A. As-builts: Shall be submitted in accordance with Section 01720.
- B. Shop Drawings: Contractor shall furnish to CFPUA Engineering shop drawings and material specification sheets of all material and items to be installed or delivered as specified in Section 01340: Submittals.

1.3 REFERENCES

- A. ASTM D1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- B. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- C. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Pressure-rated pipe (SDRSERIES).
- D. ASTM D2152 - Test Method for Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion.
- E. ASTM D2321 - Underground Installation of Flexible Thermoplastic Sewer Pipe.
- F. ASTM D2412 - External Loading Properties of Plastic Pipe by Parallel-Plate Loading.
- G. ASTM D2444 - Impact Resistance of Thermoplastic Pipe and Fittings by Means

of a Tup (Falling Weight)

- H. ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- I. ASTM D-3212 - Elastomeric push-on joints for plastic pipe.
- J. AWWA C600 - Installation of Ductile - Iron water mains and appurtenances.
- K. AWWA C900 - PVC Pressure Pipe 4 inch through 12 inch.
- L. AWWA C905 - PVC Pressure Pipe 14 inch through 36 inch.
- M. ASTM D2672 - Bell-End Poly (Vinyl Chloride) (PVC) Pipe.
- N. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- O. ASTM F478 - Precast Concrete Manhole Risers and Tops.
- P. ASTM C497 - Concrete Pipe, Manhole Sections, or Tile
- Q. ASTM F679 - Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
- R. ASTM A746 - Ductile Iron Gravity Sewer Pipe
- S. ASTM F794 - Poly (Vinyl Chloride) (PVC) Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

PART 2 PRODUCTS

2.1 POLYVINYL CHLORIDE (PVC) PIPE

- A. Sewer mains with depth of earth cover greater than 3 feet.
 - 1. For pipe sizes 4" and 6" pipe shall be SCH 40 conforming to the requirements of ASTM D1785 with solvent weld joints conforming to ASTM D2672.
 - 2. For pipe sizes 8" through 12", pipe shall be Class 150, DR18 conforming to the requirements of AWWA C900 with elastomeric push-on joints conforming to ASTM D3212 or ASTM D3139.
 - 3. For pipe sizes 14" through 24", pipe shall be Class 235, DR18 conforming to the requirements of AWWA C905 with elastomeric push-on joints conforming to ASTM D3212 or ASTM D3139.

4. For pipe sizes larger than 24" pipe shall be closed profile conforming to the requirements of ASTM F794 with a minimum pipe stiffness of 46 PSI and with elastomeric push-on joints conforming to ASTM D 3212 or ASTM D3139.
- B. Couplings shall be mechanical joint ductile iron.
- C. Pipe and fittings used for sewer service laterals shall be 4" or 6" schedule 40 conforming to ASTM D1785 with solvent welded joints.
- D. Fasteners shall be 316 stainless steel or better where exposed to sewer or sewer gases.

2.2 DUCTILE IRON PIPE

Ductile Iron Pipe: Conforming to ASTM A746, ANSI/AWWA C151/A21.51, Class 350, lined with Protecto 401 ceramic epoxy, "Sewpercoat" or approved equal unless otherwise shown or specified.

- A. Joints shall be rubber gasket push-on, conforming to ANSI/AWWA C111/A21.11, or mechanical joint conforming to ANSI/AWWA C110/A21.10, as modified by ANSI/AWWA C151/A21.51.
- B. Fittings and specials shall be suitable for 150 pounds per square inch pressure rating, unless otherwise specified. Fittings and specials for mechanical joint pipe shall conform to ANSI/AWWA C110/A21.10. Fittings and specials for use with push-on joint pipe shall conform to ANSI/AWWA C111/A21.11 lined with protecto 401 ceramic epoxy, "Sewpercoat" or approved equal unless otherwise shown or specified.

2.3 PIPE COUPLINGS

Couplings between dissimilar pipe materials (PVC to ductile iron) shall be mechanical joint ductile iron only or adapter conforming to ASTM 3139 lined with Protecto 401 ceramic epoxy, "Sewpercoat" or approved equal unless otherwise shown or specified. For pipes 8" and larger, manholes are also acceptable. Fernco couplings are NOT permitted.

2.4 MANHOLES

- A. Manholes shall be precast concrete only conforming to ASTM C478.
 1. Joint surfaces between bases, risers and cones shall be manufactured to the joint surface design and tolerance requirements of ASTM C76.
 2. Flexible joint sealants shall be butyl rubber based conforming to Federal Specification SS-S-210A, AASHTO M-198, Type B - Butyl Rubber and as

follows: maximum of 1% volatile matter and suitable for application temperatures between 10 and 100 degrees F.

3. Joints between precast components shall be sealed between the tongue and the groove and additionally around the internal and external perimeter as follows:
 - a. Tongue and groove seals shall consist of a plastic or paper-backed butyl rubber rope no less than 14 feet long and having a cross-sectional area no less than the annular space times the height of the joint.
 - b. Internal seals shall consist of Type S mortar grout.
 - c. External seals shall consist of Type S mortar grout or plastic or paper-backed butyl rubber rope no less than 14 feet long and having a cross-sectional area no less than the annular space times the height of the joint.
4. Pipe to manhole connectors shall conform to ASTM C923. The location of the pipe connectors shall vary from the location shown on the project plans no more than ½ inch vertically and 5 degrees horizontally. Provide for control of the pipe OD to within the tolerances of the connector on flexible pipes larger than 12 inches.
5. Concrete shall conform to ASTM C478 and as follows:
 - a. Compressive strength: 4000 psi minimum at 28 days.
 - b. Air Content: 4 percent minimum.
 - c. Cementitious Materials: Minimum of 564 pounds per c.y.
 - d. Coarse Aggregates: ASTM C33.
 - e. Fine Aggregates: ASTM C33. Free from organic impurities.
 - f. Chemical Admixtures: ASTM C494. Calcium Chloride or admixtures containing calcium shall not be used.
 - g. Air Entraining Admixtures: ASTM C260.
6. Mortar: ASTM C270, Type S.
7. Grout: Grout for sealing openings and joints in manholes shall be Type S mortar. No Preco or Hydraulic Cement shall be permitted.
8. Brick: Brick shall be used to bring manhole rings to grade or filler for forming manhole inverts only and shall conform to ASTM C62 Grade SW or ASTM C32 Grade MS.
9. Manholes 4' deep or less shall have an eccentric cone or a flat top.
10. Manholes over 4 feet deep shall have an eccentric cone.

11. Manholes shall have a minimum inside diameter of 4 feet for sewer mains 18 inches diameter and smaller manholes shall be 5 feet inside diameter for sewer mains larger than 18 inches. Larger inside diameters may be required for larger pipe sizes, more than two pipes, or when entrance/exit angle requires.
12. Drop manholes shall be inside drop with a minimum inside diameter of 5 feet.
13. 5 foot diameter manholes shall have a 8 inch extended base. For 4 foot diameter manholes shall have a 6 inch extended base. All extended bases shall have a minimum thickness of 6-inches.
14. Manhole steps shall be provided in bases, risers, cones, transition cones and transition top sections aligned vertically on 16" centers. Steps shall be secured to the wall with a compression fit in tapered holes or cast in place. Steps shall not be vibrated or driven into freshly cast concrete or grouted in place. The steps shall be Copolymer Polypropylene Plastic reinforced with a ½" diameter grade 60 bar and have serrated tread and tall end lugs. Step pullout strength shall be tested according to ASTM C497.
15. Sewer Guard Manhole Inserts: Each manhole shall be equipped with an insert of high density copolymer meeting the requirements of ASTM 124 with gas and vacuum relief valves matching manhole covers and rings. The insert shall be similar or equal to Sewer Guards manufactured by Southwestern Packing and Seals. Manholes located in traffic areas shall have stainless steel sewer guards by Southwestern Packing and Seals or approved equal. This is also required for grease interceptor hatches.
16. Manhole interiors that are required to be lined shall be coated with Zebron 386, Duramar 1030 as manufactured by Sewerkote, or equal as approved by CFPUA Engineering staff. Coal tar epoxy linings and Raven Lining Systems are not acceptable if field applied.
17. All in place penetrations into manholes must be by core boring methods including main line and service drops. Properly sized elastomeric boots shall be set in penetrations. The boot and the pipe must be fully mortared on the inside and the outside of the manhole.
18. Inside drop for sewer mains and services shall conform to the detail with all material to be 316 stainless steel or better, excluding piping. Drop pipe shall be anchored to the manhole as shown on the detail with intermediate supports on 30-inch spacing as required.
19. Vents shall be constructed of aluminum or type 316 steel or better and shall extend a minimum of 2 foot above 100-year flood and equipped with a non-corrosive bug screen. The maximum spacing is 1,000 feet separation between vented manholes.

B. Grey Iron Castings:

1. Manhole Castings: All iron casting for manhole frames and covers, inlet frame and traps and other sewer appurtenances, unless other specified, shall conform to ASTM A48 "Grey Iron Castings: Class 35B" and shall be marked "Sanitary Sewers". Standard and watertight frames shall have a 24 inch clear opening. Standard covers shall have up to four 1" diameter vent holes. All covers shall have lifting bars in lieu of pickholes. Watertight covers are required on all manholes where the rim elevation is less than 1 foot above the 100-year flood. All manhole castings shall be American made or machined to insure proper fit. Any manhole shall be rejected if, in the sole opinion of the CFPUA Engineering staff, the frame and cover or installation is unacceptable.
 - A. Standard frames and vented cover, manufacturer and style to be approved by a submittal to the CFPUA Engineering staff. The following are approved for use on CFPUA systems:
 1. U.S. Foundry 725 ring and DP cover
 2. East Jordan Iron Works 7 ½" Frame (in traffic areas) Product #202711, 4" Frame Product #202611 - Cover Product #202746
 3. U.S. Foundry 710 ring and DP cover (in traffic areas)
 4. Capitol Foundry of Virginia, Item MH-3000 ring & cover.
 5. General Foundries, Inc., Item GFI-7126, frame & cover (in traffic areas).
 6. General Foundries, Inc., Item GFI-4126, frame & cover.
 - B. Watertight frames and non-vented cover, manufacturer and style to be approved by submittal by the CFPUA Engineering staff. The following are approved for use on CFPUA systems:
 1. U.S. Foundry 725 ring and DP-SSG cover
 2. East Jordan Iron Works 7 ½" Frame and Cover Assembly (in traffic areas) Product #202701, 4" Frame Product #202611 - Cover Product #202722
 3. U.S. Foundry 710 ring and DP-SSG cover (in traffic areas)
 4. Capital Foundry of Virginia, Item MH-3000-WT ring & cover.

2. Cleanouts: A nominal 6" diameter by 12" cast-iron box and cover shall be furnished and installed flush with the final grade as per standard detail. "C.O." shall be stamped on lid. The box shall conform to the standard detail.
3. Adjusting Rings:
 - A. Concrete adjusting rings shall be pre-cast and conform to ASTM C478.

PART 3 EXECUTION

3.1 PIPE INSTALLATION

- A. Install PVC pipe in strict accordance with ASTM D2321. Install manholes as indicated on the plans. Install Ductile Iron Pipe in accordance with AWWA C600. Excavation and backfill shall be accomplished as specified under Section 02220 - "Excavating, Grading, Trenching & Backfilling".
- B. Pipe shall be kept clean at all times, and no pipe shall be used in the work that does not conform to the appropriate ASTM Specifications. The laying of pipe in finished trenches shall commence at the lowest point, with the spigot ends pointing in the direction of the flow. All pipe shall be laid with the ends abutting accurately to the lines and grades as shown on the plans, or as directed by the Owner. They shall be carefully centered so that when laid they will form a sewer with uniform invert.

Preparatory to making pipe joints, all surfaces of the portion of the pipe to be jointed or of the factory made jointing material shall be clean and dry. Lubricants, primer, adhesives, etc., shall be used as recommended by the pipe or joint manufacturer's specifications. The jointing material or factory fabricated joints shall then be placed, fitted, and adjusted in such workmanlike manner as to obtain the degrees of water tightness required. Trenches shall be kept dry during bedding, laying and jointing and for as long a period as required. As soon as possible after the joint is made, sufficient backfill material shall be placed along each side of the pipe to offset conditions that might tend to move the pipe off line and grade.

Where more than one pipe line is laid in the same trench and the invert elevations are not identical, and where no concrete cradle or encasement is provided for the support of the higher pipe line, its foundation shall be considered to be yielding. When bridging is required to support a portion of the pipeline over such yielding trench bottom, the pipe line itself shall not be considered to provide bridging strength, and supplementary materials for this purpose shall be provided.

- C. No superficial loads shall be placed on the exposed surface of the trench, unless the backfill is of non-cohesive material, is vibrated or is tamped in layers not exceeding 6-inches in depth, until the Owner is satisfied that sufficient settlement has occurred

to alleviate undue live or impact loads. Any defects due to settlement shall be corrected by the Contractor. Bell holes shall be dug sufficiently large to insure the making of proper joints. Water shall not be allowed to rise in the excavation until the joint material has received its set. Great care shall be used to secure water tightness, and to prevent damage to or disturbing of the joints during the backfilling process, or at any other time. Special precautions shall be exercised to prevent any pipe from resting on rock or any other hard projection which might cause breakage of pipe. During construction, the mouth of the completed pipe shall always be kept properly closed with a suitable plug to prevent the entrance therein of any water, earth, stones or other debris. The Contractor shall also take any and all measures to keep the pipe clean and free from deposits and protect the pipe from damage.

- D. **Cleaning Pipe:** The pipes shall be thoroughly cleaned before they are laid and shall be kept clean until acceptance of the completed work. The upper end of all pipe lines shall be provided with a header carefully fitted, so as to keep dirt and other substances from entering. This header shall be kept in the end of the pipe line at all times when laying is not in actual progress.
- E. **Shoring, Sheet piling and Well-Pointing:** The Contractor shall include in his price bid for pipe the placing of all necessary shoring, sheet piling and well-pointing, gravel bedding, and any other dewatering devices to prevent damage to other installations and where required by the Owner.
- F. **Service Connecting:** Sewer laterals shall be connected to the main by means of a wye fitting installed in the top quadrant of the pipe but shall not be installed straight up. Where it is necessary to lay new house services or relay or tie in existing house services, the Contractor shall use the materials and type joints as set forth on the plans, as given in the specifications, or as directed by the Engineer. These services shall be sized as designated on the plans or as shown on details. The service connection shall be located such that a minimum clearance of 25 feet is provided between potable water wells and sanitary sewer lines.

Service piping shall be perpendicular with the main unless otherwise approved by the Engineer. Where new mains are being laid, the house service shall be connected to the main by means of a wye set in the main with the branch turned up in such manner that a good square connection will be made with the grade of the house service. Service pipe shall connect to the main at manholes when noted on the drawings or when requested by the Engineer by core boring the manhole and field installation of the proper size elastomeric boot mortared inside and outside of the manhole. Service lines that enter manholes shall enter on the shelf or at a minimum of crown to crown for the receiving pipe. Service lines shall be terminated at property line or edge of easement as shown on Standard Detail.

All house connections shall be laid to a point from the property line as shown in details. Contractor shall provide a clean-out and stub solvent weld cap as shown in details. During installation, any services or utilities damaged by the Contractor shall be properly maintained and repaired by the Contractor at his expense.

All house laterals installed under paved streets shall be installed by the compacted bore method. Where conditions prohibit the use of the compacted bore method, alternate methods may be used as approved by the Engineer.

- G. Clean-outs: Clean-outs shall be located as per standard detail, and at a minimum of 12 feet from all property corners. A 6 inch diameter cast-iron box and cover shall be provided over clean-out plug. The cast iron box shall be marked by a landscape timber 2 feet in the ground and 2 feet exposed above ground.
- H. Pavement Replacements: Where it is necessary for the Contractor to cut, drop, or otherwise remove pavement to install sewer lines, the Contractor shall replace all pavement in accordance with the Section 02513: "Asphalt Concrete Paving" of these specifications.
- I. Salvage: All salvage materials of whatever nature shall be disposed of at the direction of the Engineer. Particularly care must be exercised in handling salvaged materials by the contractor.

3.2 MANHOLE INSTALLATION

- A. General: Manholes shall be constructed of pre-cast concrete rings in accordance with the Drawings. The pre-cast concrete base shall be placed on a six inch (minimum) stone bedding foundation which shall extend up around the pipes to at least 3 inches above the top line of the pipes. The stone bedding shall be considered as incidental to the unit price bid for the installed manhole. Pipes entering the pre-cast sections of the manhole shall be inserted into the adaptor couplings provided. All pre-cast manhole components shall be lifted and moved by use of suitable lifting slings and plugs that will not damage the pre-cast manhole lip.

All damage to pre-cast sections shall be thoroughly repaired in the presence of the Engineer. Repair and patching of minor breaks shall be done by chipping and scarifying the defective area before application of grout. Pre-cast sections shall be subject to rejection on account of failure to conform to any of the specification requirements. In addition, individual sections of manhole sections may be rejected because of fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint; defects that indicate imperfect proportioning, mixing, and molding; surface defects indicating honey-combed or open texture; damaged or cracked end, where such damage would prevent making a satisfactory joint; and/or any continuous crack having a surface which width of 0.01 inches or more and extending for a length of 12 inches or more, regardless of position in the section wall.

- B. The Contractor is responsible for getting the manhole tops to proper grade. Profiles on the plans are for cost estimates only. The top of the pre-cast manhole may be brought to proper grade for receiving manhole frames by using brick with a maximum adjustment of 12 inches from pre-cast cone to the cast iron ring. Masonry construction shall be preformed by experienced and qualified workmen. All work shall be laid plumb, straight, level, square, and true. The Contractor shall set and bond

the manhole frame in a full bed of mortar. All manhole steps and miscellaneous items shall be properly bedded. The masonry walls shall be parged on the inside and outside with a ½-inch coat of Type S mortar.

Wedging or the placing of the shims to secure proper level will not be used in setting of manhole sections. Manholes located in unpaved roads shall be constructed with top of lid located 8 inches below road surface and a concrete reference marker shall be placed at the adjacent right of way line.

- C. Invert Channels: The invert channels shall be 3/4 the depth of the largest pipe and shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of channels shall be made gradually and evenly. The invert channels shall be formed directly in the concrete of the manhole base or shall be built up with solid brick and Type S mortar.

All upstream pipes (including services) shall have sloped invert channel slides that provide smooth transitions to the downstream invert channel. Invert channel slides shall be the diameter of the entering pipe and be formed as a channel that is at least 3/4 pipe deep. Upstream pipes that enter at the shelf shall have their invert channel slides smoothly cast into the shelf with a sloping transition to the downstream pipe invert.

The floor of the manhole outside the channels, or slides, shall be smooth and shall slope toward the channels not less than 1 inch per foot nor more than 2 inches per foot. No laser bowl invert manholes shall be permitted.

- D. Grade Rings: Manhole castings shall be installed to grade using 24 inch inside diameter pre-cast concrete grade rings, or brick grouted in place, for a maximum adjustment of 12 inches. Manhole sections shall be used for greater adjustment, unless approved otherwise. Flat top manholes shall not be adjusted by more than one course of brick.
- E. Drop Manholes: Inside drop only with minimum 5' diameter. Where sewer lines enter on a grade 30 inches or more above the invert of the discharge line, a drop manhole shall be constructed as directed by the Engineer. The drop or drops, shall be constructed in accordance with the Standard Detail, as shown on the plans, of 316 stainless steel or better excluding pipe with intermediate supports on 30-inch spacing as required.

3.3 CUTTING OF PIPE

Cut pipe in a neat manner without damage to the pipe or any fittings or specials.

3.4 ADJACENT FACILITIES

A. Water Mains

1. Horizontal and Vertical Separation

- A. Minimum horizontal separation between gravity sanitary sewer lines and existing or proposed water mains (measured edge of pipe to edge of pipe) shall be 10 feet for PVC pipe. Any deviation from the minimum separation shall involve the water main in a separate trench or on an undisturbed earth shelf located on one side of the sewer at an elevation so the bottom of the water main is at least 18 inches above the top of sewer.
- B. If it is impossible to obtain proper horizontal and vertical separation as described above or anytime sewer must be laid above a water main, both the water main and sewer main must be constructed of class 350 ductile iron pipe and prepared for pressure testing to 150 psi to assure water-tightness before backfilling.

2. Crossings

- A. Sewers crossing water mains shall be laid to provide a minimum vertical separation of 18 inches between the bottom of the water main pipe and the top of the sewer pipe. The crossing shall be arranged perpendicularly so that the sewer joints will be equidistant and at least 10 feet from the crossing in each direction.
 - B. When it is impossible to obtain proper horizontal and vertical separation as stipulated above, one of the following methods must be specified:
 - i. The sewer shall be designed and constructed of class 350 ductile iron pipe and prepared for pressure testing to 150 psi to assure water-tightness prior to backfilling, or
 - ii. Either the water main or the sewer line may be encased in a watertight carrier pipe which extends 10 feet on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be of materials approved by the CFPWA Engineering staff for use in water main construction. All joints of pipe inside carrier pipe shall be class 350 ductile iron with mega-lug mechanical joints throughout.
- 1. No manhole shall be placed within 100 feet of a well utilized for potable water.
 - 2. No sewer piping shall be placed within 25 feet of a well utilized for potable water.
 - 3. Minimum specifications for sewer piping placed between 25 feet and 50 feet of a well utilized for potable water shall meet or exceed the requirements Class 350, ductile iron with push on joints conforming to ANSI A21.50/A21.51

lined with Protecto 401 ceramic epoxy or approved equal.

- C. Storm Drains: Provide 24 inches of soil between sewer lines and storm drains. When a 24 inch minimum separation cannot be achieved, use ductile iron pipe and/or structural bridging to provide the required support. The ductile iron pipe shall extend a minimum distance of 10 feet centered at the storm drain. Where sanitary sewer is installed under existing storm drain structures or pipe, flowable fill as approved by CFPWA Engineering staff and N.C. Department of Transportation (where applicable), must be used where proper compaction cannot be obtained.
- D. Roads and Ditches: Provide 36 inch minimum cover for PVC beneath the roads and ditches. When a roadside ditch is perpendicular to the sewer service, a minimum cover of 24 inch will be allowed. Otherwise construct the sewer of ductile iron pipe or encase the pipe in concrete.

3.5 MINIMUM GRADE (Unless otherwise directed or shown on the plans)

- A. 4 INCH PIPE: One foot per 100 feet (1.0 percent).
- B. 6 INCH PIPE: 0.6 feet per 100 feet (0.6 percent).
- C. 8 INCH PIPE: 0.4 feet per 100 feet (0.4 percent).
- D. 10 INCH PIPE: 0.28 feet per 100 feet (0.28 percent).
- E. 12 INCH PIPE: 0.22 feet per 100 feet (0.22 percent)

3.6 BACKFILL

Materials and installation of pipe bedding haunching and backfill shall be in accordance with Section 02220, "Excavating, Grading, Trenching and Backfilling".

3.7 SERVICE CONNECTIONS

- A. Service Connection: Install at locations shown on the drawings, or as designated by the Owner's representative. Service connections shall consist of wye branch, fittings, cleanout, cast iron box and cover, and pipe, as detailed on the drawings. Set cleanout box on 4 inches of stone.
- B. A SAMPLING CHAMBER IS REQUIRED ON ALL COMMERCIAL DEVELOPMENTS. When a CFPWA approved grease interceptor is required, the sampling chamber can be removed from the design.

3.8 FIELD QUALITY CONTROL

Field inspection, sampling and testing will be performed per Owner's instructions.

3.9 SALVAGE

All salvage materials of whatever nature shall be disposed of at the direction of the Engineer. Particularly care must be exercised in handling salvaged materials by the Contractor.

3.10 TESTING

General: The Contractor shall be responsible for providing all equipment necessary for tests of displacement, deflection, and leakage. Tests for deflection and leakage shall be performed by the Contractor and observed by CFPUA Engineering Staff. Each segment of line shall be tested:

1. 30 days prior to final acceptance of the project, all segments of main and all services shall be cameraed in the presence of the Authority's representative at no cost to the Authority. If acceptance is not required, the camera work may still be required by CFPUA Inspector.
2. After two (2) paper copies of the as-builts have been submitted to CFPUA.
3. After gravel has been installed on all roadways.
4. After forty-eight (48) hour notice is given to CFPUA Engineering staff.

The camera inspection must be performed upon completing of cleaning and potable water introduced into the system to be tested. All defects in the pipeline and appurtenances shall be remedied by the Contractor at no additional expense to the CFPUA and will be reinspected as outlined above. Acceptance of any deviation from these requirements is at the sole discretion of the Authority.

- B. Test for Deflection: Deflection tests may be performed on all sections of flexible pipe.
1. Maximum allowable deflection shall be 5 percent at any point.
 2. Deflection shall be measured with a pin-type mandrel "Go/No Go" gauge. The gauge shall be pulled through the pipe by means of a strong cord or cable.
 3. Any section of pipe not meeting the 5 percent maximum deflection requirement shall be excavated, backfilled, re-compacted and retested.
- C. Test for Leakage: All segments of completed line may be tested for leakage by low pressure air test, except that the infiltration test may be used as approved by the Owner's representative. The Authority may choose to camera the pipe. Acceptance of any deviation from these requirements is at the sole discretion of the CFPUA.

1. The Contractor shall remedy all visible leaks in pipes, manholes, and appurtenances.
2. Maximum allowable leakage for the system shall be 0 gallons per inch pipe diameter per linear mile of pipe per 24 hours, including manhole infiltration. No single segment of line (manhole to manhole) shall exceed this requirement.
3. Air Testing: Air testing shall be required if, in the sole opinion of the CFPUA, conditions are such that infiltration measurements may be inconclusive. The test shall be conducted in the presence of the CFPUA Engineer and shall conform to the following requirements:
 - a. Test pressure shall be 3.5 psi increased by the ground water pressure above the top of the sewer.
 - b. Pressure loss from 3.5 psi shall not exceed 0.5 psi during the required testing time.
 - c. Testing time in minutes shall be calculated as $0.625 \times \text{nominal pipe size (inches)}$.

D. Testing Manholes:

1. Each manhole may be tested immediately after assembly and prior to backfilling.
2. All lift holes shall be plugged with an approved Type "S" grout.
3. All pipes entering the manhole shall be plugged, taking care to securely brace the plug from being drawn into the manhole. Unless plugs are mechanically restrained, it is recommended that the plugs are used with a minimum of 2 times safety factor above the test pressure.
4. The test head shall be placed at the inside of the top of the cone section and the seal inflated in accordance with the manufacturers' recommendations.
5. A vacuum of 10 inches (5 psig) of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to 9 inches. The manhole shall pass if the time is greater than 60 seconds for 48 inch diameter, 75 seconds for 60 inch.
6. If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn. You shall retest until a satisfactory test is obtained.
7. After the gravity sewers and manholes have been installed and backfilled, the manholes shall be inspected for leakage. No visible leaks will be permitted.

- E. Test Results: Certified copies of all test results shall be furnished to the Owner and the CFPUA Engineering staff within 1 week after the test.

PART 4 PAYMENT

4.01 PAYMENT

Payment for this section shall be made based on the actual measurement of work at the unit price shown in the contract proposal form. C900/905 unit pipe prices to include all cost associated with installation such as all fittings, adaptors, and specials installed complete in place.

END OF SECTION 333111

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SECTION 333123 - WASTEWATER FORCE MAINS

NOTE: THE BELOW SPECIFICATIONS WERE DERIVED FROM CFPUA STANDARD SPECIFICATION SECTION 02732 – REVISED 10/11/10. ALTERATIONS TO THE CFPUA STANDARD SPECIFICATIONS HAS BEEN LIMITED TO SECTION NUMBERING AND SECTION REFERENCES FOR CONSISTENCY WITH OVERALL PROJECT DOCUMENTS.

PART 1 GENERAL

1.1 WORK INCLUDED

- A. This section covers the installation of wastewater force mains, including pipe, valves and service connections. Excavation, trenching and backfilling are covered in Section 312213: "Excavating, Grading, Trenching, & Backfilling".
- B. The foreman of the contracting crew must speak fluent English.

1.2 RELATED WORK

- A. Section 312213: "Excavating, Grading, Trenching, & Backfilling"
- B. Section 221429: Grinder Pump Station
- C. Section 333111: "Gravity Sanitary Sewer System"

1.3 GENERAL

- A. Piping for wastewater force mains: 2-inch force mains shall be SDR21 Casketed PVC. Force mains larger than 2-inch shall be DR 18 PVC. Other piping material only allowed as approved by CFPUA Engineering staff.

1.4 REFERENCES

- A. ASTM D2241 - Poly (Vinyl Chloride) (PVC) plastic pipe (SDR-PR).
- B. ASTM D3139 - Joints for plastic pipe using elastomeric seals.
- C. ASTM F477 - Elastomeric seals for jointing plastic pipe.
- D. ASTM D1785 - Poly (Vinyl Chloride) (PVC) plastic pipe, schedules 40, 80 and 120.
- E. ASTM D2467 - Socket - Type Poly (Vinyl Chloride) (PVC) plastic pipe fittings, schedule 80.

PRODUCTS

2.1 Wastewater Force Mains

- A. Pipe shall conform to requirements of Class 150 (DR18) C900 or class 235 (DR18) C905. Joints shall conform to ASTM D3139 and Gaskets to ASTM F477.

- B. Mechanical Joint: Suitable for 150 pounds per square inch minimum pressure rating. Fittings and specials shall conform to ANSI/AWWA C153/A21.53.
- C. Ductile iron pipe shall conform to ANSI/AWWA C150/A21.50, ANSI/AWWA C151/A21.51, Class 350 shall be lined with ceramic epoxy lining Protecto 401 or equal.

2.2 GATE VALVES

- A. Iron body, bronze mounted, double disc, parallel seat type meeting the full requirements of AWWA C500, or resilient seated in conformance with AWWA C509 or C515, with a minimum working pressure of 150 pounds per square inch. Valves shall have 2 inch operating nut and open left, and shall have O-ring seals. Valve ends shall be mechanical joint, unless otherwise shown or specified. Valves shall be manufactured by Mueller, American Darling or Clow Corporation or approved equal. Direct bury of plug valves is not allowed.

2.3 VALVE BOXES AND COLLARS

- A. Valve Boxes shall be cast iron screw-type adjustment type with flared base. The word "SEWER" shall be cast in the cover. The boxes shall be of such length as will be adapted, without full extension, to the depth of cover required over the pipe at the valve location. Boxes shall be installed over each valve, unless otherwise shown or specified. Valve boxes shall conform to ASTM A48" grey iron castings, class 303.
- B. Valve box concrete collars: Valve boxes in unpaved areas shall be installed with pre-cast concrete collars.

2.4 PIPE MARKING TAPE

- A. Tape shall be 3 inches wide, green in color, bearing continuous message "CAUTION SEWER LINE BURIED BELOW." Tape shall be made of plastic or other permanent material with metalized foil core and shall be installed 18" above the installed line.
- B. A 10 gauge insulated copper wire shall be run continuously along the pipe and shall be securely taped to the water line. All splices in the wire shall be made by use of an underground rated, watertight, and approved splice connector. No twisting of wire ends is permitted. The locator wire shall not be wrapped around the pipe, flanges, bells, valves, or other appurtenances. The locator wire shall be accessible above ground at one thousand feet (1,000') intervals and shall be protected by a cast iron box with cover marked "sewer" with a concrete collar. At valve boxes, the wire shall be brought up on the outside of the box and folded under lid.

2.5 SEWAGE AIR AND VACCUM VALVES

- A. Air and Vacuum Valve: Combination air release and vacuum valves shall be the long stem and body type designed to keep the valve operating mechanism as free from contact with the sewage as possible. The valves shall allow unrestricted venting or re-entry of air during filling or draining of the force main. Valve shall incorporate two (2) stainless steel floats with stainless steel connecting float guide. All internals shall be removable through the top cover. Valves shall have a 2" NPT threaded inlet and 1" NPT outlet, with 1" blow off connection with 1" blow off valve (gate valve), ½" back flushing attachments with ½" outlet. Valves shall also have outlet and back flushing connections with quick disconnects and 5' of hose. The valve shall satisfactorily withstand hydrostatic pressures of 300 psi. Valves shall be manufactured for use in sanitary sewer. Valves shall be either APCO Valve Series 440 SCAV, or A.R.I. USA Inc. series D-025 SAAR, or approved equal. Valves shall be mounted on McDonald 3800 Series saddle for 10" force mains or smaller, and a full tee with blind flange for force mains larger than 10", with 316G stainless steel or better valve and nipples.
- B. Air release valves shall be installed where the distance between the low point and high point in the force main exceeds 10 vertical feet.
- C. Air and Vacuum Valve Manhole: Ring, cover and 5' diameter precast manhole shall conform to the plans and with Section 02731 of these specifications.

2.6 MECHANICAL JOINT RESTRAINT GLAND

- A. Mechanical joint restraint shall be incorporated in the design of the follower gland and shall include a restraining mechanism which, when actuated, imparts multiple wedging action against the pipe, increasing its resistance as the pressure increases. Flexibility of the joint shall be maintained after burial.
- B. Glands shall be manufactured of ductile iron conforming to ASTM A536-80. Restraining devices shall be of ductile iron heat treated to a minimum hardness of 370 BHN. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee-head bolts conforming to ANSI/AWWA A21.11 and ANSI/AWWA C153/A21.53 of latest revision. Twist-off nuts shall be used to insure proper actuating of the restraining devices.
- C. The Mechanical joint restraint device shall have a working pressure of at least 250 psi with a minimum safety factor of 2:1.
- D. Restraint glands shall be "Mega lug" as manufactured by EBAA Iron, Inc.

2.7 FITTINGS & SPECIALS

Fittings and specials shall be class 54 ductile iron, mechanical joint in accordance with ANSI/AWWA C111/A21.11, ANSI/AWWA C153/A21.53, 150 pounds per square inch pressure rating unless otherwise shown or specified, except that profile of bell may have special dimensions as required by the pipe manufacturer with elastomeric gaskets. Ductile iron fittings and specials shall be lined with ceramic epoxy protecto 401 or equal.

PART 3 EXECUTION

3.1 GENERAL

- A. Install PVC and ductile iron pipe in strict conformance with AWWA C600 and the recommendations of AWWA Manual of Practice M23. Minimum depth of bury above the top of pipe shall be 36 inches.

3.2 CUTTING OF PIPE

- A. Cut pipe in a neat manner without damage to the pipe or its lining.

3.3 ADJACENT FACILITIES

- A. Sewer Lines: Where the location of the sewer pipe is not clearly defined in dimensions on the drawings, the sewer pipe shall not be laid closer horizontally than 10 feet from a water line except where the bottom of the water pipe will be at least 18 inches above the top of the sewer pipe. Where water lines are less than 18 inches above the sewer lines, or cross under sewer lines (must be approved on a case by case basis), the sewer pipe and water pipe for a distance of at least 10 feet each side of the crossing shall be made of ductile iron pressure pipe with no joint located within 8 feet horizontally of the crossing.
- B. Force mains shall not be laid in the same trench with water lines, gas lines or electric wiring.
- C. Wells
 - 1. No force main shall be placed within 25 feet of a well utilized for potable water.
 - 2. Minimum specifications for force mains placed between 25 feet and 50 feet of a well utilized for potable water shall meet or exceed the requirements Class 50, ductile iron with push on joints conforming to ANSI A21.50/A21.51 lined with Protecto 401 ceramic epoxy or approved equal.

3.4 PIPE DEFLECTION

- A. Maximum pipe deflection shall not exceed manufacturer's recommendations.

3.5 JOINTING

- A. PVC Pipe: Install in accordance with AWWA Manual of Practice M23, modified as necessary by the recommendations of the manufacturer.
- B. Connections between different types of pipe and accessories shall be made with transition fittings approved by the CFPWA Engineering staff.

3.6 SETTING OF VALVES AND VALVE BOXES

- A. Valves and Valve Boxes: Install where shown or directed and set plumb. Valve boxes shall be centered on the valves. Boxes shall be installed over each outside gate valve. Where feasible, valves shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face if less than 4 feet. Valve cover shall be cast with "SEWER" on top. A concrete collar must be installed with all valve boxes in unpaved areas.
- B. Valves after delivery shall be drained to prevent freezing and shall have the interiors cleaned of all foreign matter before installation. Stuffing boxes shall be tightened and the valve shall be fully opened and fully closed to insure that all parts are in working condition.

3.7 RESTRAINING/BLOCKING

The plugs, caps, tees and bends deflecting 22-1/2 degrees or more either vertically or horizontally on force mains 4-inches in diameter or larger shall be provided with thrust blocking or "Mega lug" retainer gland at each joint installed per manufacturer's requirements. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust blocks shall be poured directly against undisturbed earth. The sides of thrust blocks not subject to thrust may be poured against forms. The area of bearing shall be as shown on the plans or as directed. Blocking shall be placed so that the fitting joints will be accessible for repair. Steel rods and clamps shall be type 316 stainless steel or better.

3.8 POST-CONSTRUCTION CLEANING

- A. After construction of the force main has been completed and before hydraulic testing is done, the contractor shall clean the inside of the force main by means of pigging or other approved methods. During the cleaning, the force main shall be cleaned free of all foreign growths, slurries, debris or other matter, leaving the inside periphery of the pipe smooth and as free from irregularities as the type of conduit will permit. Any method used must have the ability to negotiate any fabricated mitered bends, short radius elbows, pass-through tees, crosses, and multi-dimensional pipe sizes and valves.

3.9 HYDROSTATIC TESTS

- A. General: Where any section of a sewer line is provided with concrete thrust blocking the hydrostatic test shall not be made until at least 5 days after installation of the concrete thrust blocking unless otherwise approved. The method proposed or disposal of wastewater from hydrostatic tests and disinfection shall be submitted to the Owner prior to performing hydrostatic tests. Use clean potable water for all testing of lines.
- B. Pressure Test: Pressure test in strict conformance with AWWA C600, Section 4.1 and AWWA Manual of Practice for M23. For purposes of testing, working pressure shall be 100 psi and test pressure shall be 150 psi. Air testing will not be accepted (ONLY Hydrostatic testing is allowed).
- C. Leakage Test: Test for leakage concurrent with the pressure test and in strict conformance with AWWA C600, Section 4.2 and AWWA Manual of Practice M23. Remedy all visible leaks and locate and repair leakage in lines which exceed the specified amounts.

3.10 FIELD QUALITY CONTROL

- A. Field inspection, sampling and testing will be performed per Owner's instructions.

PART 4 PAYMENT

4.01 PAYMENT

Payment for this section shall be made based on the actual measurement of work at the contract unit price.

END OF SECTION 333123

SECTION 334200 - STORMWATER CONVEYANCE**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Stormwater drainage piping.
2. Manholes.
3. Catch basins.
4. Cleanouts.
5. Pile support systems.
6. Concrete encasement and cradles.
7. Bedding and cover materials.

B. Related Requirements:

1. Section 033000 - Cast-in-Place Concrete
2. Section 312213 - Excavating, Grading, Trenching, and Backfilling

1.2 DEFINITIONS

- A. ABS: Acrylonitrile butadiene styrene.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Refer to Section 012000 - Price and Payment Procedures

1.4 REFERENCE STANDARDS**A. American Association of State Highway and Transportation Officials:**

1. AASHTO M036 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
2. AASHTO M196 - Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
3. AASHTO M218 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized), for Corrugated Steel Pipe.
4. AASHTO M245 - Standard Specification for Corrugated Steel Pipe, Polymer-Precoated, for Sewers and Drains.
5. AASHTO M246 - Standard Specification for Steel Sheet, Metallic-Coated and Polymer-Precoated, for Corrugated Steel Pipe.
6. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe.

7. AASHTO M274 - Standard Specification for Steel Sheet, Aluminum-Coated (Type 2), for Corrugated Steel Pipe.
8. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
9. AASHTO M289 - Standard Specification for Aluminum-Zinc Alloy Coated Sheet Steel for Corrugated Steel Pipe.
10. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter.
11. AASHTO T241 - Standard Method of Test for Helical Continuously Welded Seam Corrugated Steel Pipe.
12. AASHTO T 180 - Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
2. ASTM A123/ (A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products).
3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
4. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
5. ASTM B745/B745M - Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
6. ASTM C14 - Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
7. ASTM C14M - Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe [**Metric**].
8. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
9. ASTM C76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe [**Metric**].
10. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
11. ASTM C443M - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets [**Metric**].
12. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
13. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³).
14. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³).
15. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
16. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
17. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
18. ASTM D2680 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.

19. ASTM D2729 - Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
20. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
21. ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
22. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
23. ASTM F405 - Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
24. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
25. ASTM F667/F667M - Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings.

C. North Carolina Department of Transportation (NCDOT)

1. 2012 NCDOT Standard Specification for Roads and Structures (NCDOT RS)

1.5 COORDINATION

- A. Section 013000 - Administrative Requirements: Requirements for coordination.
- B. Coordinate Work of this Section with termination of storm sewer connection outside building, trenching, connection to foundation drainage system, and building roof drains.

1.6 PREINSTALLATION MEETINGS

- A. Section 013000 - Administrative Requirements: Requirements for preinstallation meeting.

1.7 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer information describing pipe, pipe accessories, and pipe appurtenance.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer Instructions: Submit special procedures required to install specified products.
- E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

1.8 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of pipe runs, connections, catch basins, cleanouts, and invert elevations.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.9 QUALITY ASSURANCE

- A. Perform Work according to NCDOT RS standards.

1.10 QUALIFICATIONS

- A. Manufacturer: Company specializing in performing the work of this section.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

1.12 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication.
 - 2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS**2.1 STORM DRAINAGE PIPING****A. Ductile-Iron Piping:**

1. Pipe:
 - a. Comply with ASTM A746, Class 50.
 - b. Type: Service.
 - c. Inside Nominal Diameter: as indicated on drawings
 - d. Ends: Bell and spigot.
2. Fittings: Ductile iron.
3. Joints:
 - a. Comply with ASTM A746.
 - b. Joint Devices: Rubber gasket.

B. Reinforced Concrete Piping:

1. Pipe:
 - a. Comply with ASTM C76 (C76M), Class III or as indicated on drawings
 - b. Reinforcement: Mesh or Bar.
 - c. Inside Nominal Diameter: as indicated on drawings
 - d. End Connections: Bell and spigot.
2. Fittings: Reinforced concrete.
3. Joints:
 - a. Comply with ASTM C443 (C443M).
 - b. Gaskets: Rubber, compression.

C. PVC Piping:

1. Pipe:
 - a. Comply with ASTM D3034; SDR 35 unless indicated otherwise.
 - b. Inside Nominal Diameter: as indicated on drawings
 - c. Style: Bell and spigot with rubber-ring sealed gasket joint.
2. Fittings: PVC.
3. Joints:
 - a. Comply with ASTM F477.
 - b. Gaskets: Elastomeric.

D. Corrugated PE Piping:

1. Pipe:
 - a. Comply with ASTM F667/F667M.
 - b. Type: Smooth interior.
 - c. Inside Nominal Diameter: as indicated on drawings
2. Fittings: PE.
3. Joints: Comply with ASTM F667/F667M.

2.2 MANHOLES

- A. Conform to ASTM C478. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure.

2.3 CATCH BASINS, DROP INLETS, AND CURB INLETS

- A. All stormdrain structures located in pavement areas shall be H20 load rated and shall confirm to ASTM C1433 and NCDOT RS.

2.4 Frame and Cover

Frame and cover shall be cast iron or ductile iron conforming to CID A-A-60005; designed for H20 loading. The weight, size, and shape shall be as indicated on the plans. The word storm shall be stamped or cast into covers so that it is plainly visible.

2.5 EXTERNAL SEALING BANDS

Conform to ASTM C877

2.6 BEDDING AND COVER

- A. Bedding and Cover: In accordance with NCDOT RS and manufacturer's recommendations.

2.7 MIXES

- A. Grout: Grout for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The inside joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.8 FINISHES

A. Steel Galvanizing:

1. Comply with ASTM A123/A123M.
2. Hot-dip galvanized after fabrication.

B. Galvanizing for Nuts, Bolts, and Washers: Comply with ASTM A153/A153M.

2.9 ACCESSORIES

A. Structure Steps

1. Zinc coated steel conforming to 29 CFE 1910.27.
2. As an option, plastic or rubber coating pressure-molded steel may be used. Plastic coating shall conform to ASTM D4101, copolymer polypropylene. Rubber shall conform to ASTM C433, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in structures less than 4.5 feet deep.

B. Cleanouts

1. Cast iron soil pipe for cleanouts in accordance with ASTM A74
2. Joints conforming to ASTM C564, compression type rubber gaskets; exterior protection (if required) AWWA C105/A21.5, polyethylene encasement.

C. Downspout Boots

1. Gray cast iron conforming to ASTM A48/A48M, Class 30B or 35B. Shape and size as required.

D. Resilient Connectors

1. Flexible watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923

E. Geotextile Filter Fabric:

1. Comply with AASHTO M288 for subsurface drainage.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify that trench cut and excavation base is ready to receive Work of this Section.
- C. Verify that excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Correct over-excavation with aggregate or select fill
- C. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

- A. Excavation and Bedding:
 - 1. Excavate trench to 12 inches below pipe invert, and as specified in Section 312213 Excavating, Grading, Trenching, and Backfilling.
 - 2. Hand trim excavation for accurate placement of piping to indicated elevations.
 - 3. Place bedding material at trench bottom.
 - 4. Level materials in continuous layers not exceeding 6-inch compacted depth.
 - 5. Maintain optimum moisture content of bedding material to attain required compaction density.
 - 6. Level fill materials in continuous layers not exceeding 6 inches in depth, and compact to 95 percent maximum density.
- B. Piping:
 - 1. Pipe, Fittings, and Accessories: Comply with ASTM D2321 and manufacturer's instructions.
 - 2. Seal joints watertight.
 - 3. Install aggregate bedding and haunching as indicated on the drawings.
 - 4. Install top cover to minimum compacted thickness of 12 inches and compact to 95 percent maximum density.
 - 5. Backfilling and Compaction:
 - a. As specified in Section 312213 Excavating, Grading, Trenching, and Backfill
 - b. Do not displace or damage pipe or structures while compacting.
 - 6. Connect to subdrainage and roofdrain system piping as required.
 - 7.
- C. Structures:
 - 1. Form bottom of excavation clean and smooth, and to indicated elevation.
 - 2. Form and place cast-in-place concrete base pad, with provision for storm sewer pipe end sections.
 - 3. Level top surface of base pad.
 - 4. Sleeve concrete shaft sections to receive storm sewer pipe sections.
 - 5. Establish elevations and pipe inverts for inlets and outlets as indicated on Drawings.
 - 6. Mount lid and frame level in grout, secured to top section to indicated elevation.

7. Install structures watertight

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Requirements for tolerances.
- B. Maximum Variation from Indicated Pipe Slope: 1/8 inch in 10 feet.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.

3.6 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect pipe and structures from damage or displacement until backfilling operation is in progress.

3.7 ATTACHMENTS

- A. Storm Sewer Main: From 5 feet (1.5 m) beyond north building wall, to municipal sewer under Peachtree Boulevard; 12-inch (300-mm) size; cast iron under parking areas, PVC elsewhere.
- B. Storm Sewer Branch Lines: Connect catch basins at various site locations with intersection of main sewer line near sidewalk on Center Avenue. Sizes as noted on Drawings.

END OF SECTION 334200

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SECTION 33 46 00**SUBDRAINAGE****PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Perforated-wall pipe and fittings.
 - 2. Drainage conduits.
 - 3. Drainage panels.
 - 4. Geotextile filter fabrics.

1.2 ACTION SUBMITTALS

- A. Product Data: For geotextile filter fabrics.

PART 2 - PRODUCTS**2.1 PERFORATED-WALL PIPES AND FITTINGS**

- A. Perforated PE Pipe and Fittings: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

2.2 DRAINAGE CONDUITS

- A. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advanced Drainage Systems, Inc.
 - b. American Wick Drain Corporation.
 - c. JDR Enterprises, Inc.
 - d. TC Mirafi.
 - 2. Nominal Size: 12 inches high by approximately 1 inch thick.
 - a. Minimum In-Plane Flow: 30 gpm at hydraulic gradient of 1.0 when tested according to ASTM D 4716.

3. Nominal Size: 18 inches high by approximately 1 inch thick.
 - a. Minimum In-Plane Flow: 45 gpm at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
4. Filter Fabric: PP geotextile.
5. Fittings: HDPE with combination NPS 4 and NPS 6 outlet connection.
6. Couplings: Corrugated HDPE band.

2.3 DRAINAGE PANELS

- A. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
 1. Drainage Core: Open-construction, resilient, plastic-filament mesh, approximately 0.4 inches thick.
 - a. Minimum In-Plane Flow Rate: 2.4 gpm/ft. of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig when tested according to ASTM D 4716.
 2. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. when tested according to ASTM D 4491.

2.4 SOIL MATERIALS

- A. Soil materials are indicated on Civil Drawings and Geotechnical Report.

2.5 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.
- B. Structure Type: Nonwoven, needle-punched continuous filament.
 1. Survivability: AASHTO M 288 Class 2.
 2. Styles: Flat and sock.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are indicated on Civil Drawings.

3.2 FOUNDATION DRAINAGE INSTALLATION

- A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches deep and 12 inches wide.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.
- E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.
- F. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- G. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.
- H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- I. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.
- J. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.3 PIPING INSTALLATION

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
 - 1. Foundation Subdrainage: Install piping level and with a minimum cover of 36 inches unless otherwise indicated.
 - 2. Lay perforated pipe with perforations down.
 - 3. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install thermoplastic piping according to ASTM D 2321.

3.4 PIPE JOINT CONSTRUCTION

- A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.
- B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.5 BACKWATER VALVE INSTALLATION

- A. Comply with requirements for backwater valves specified in Division 33.
- B. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.
- C. Install horizontal backwater valves in piping in manholes or pits where indicated.

3.6 CONNECTIONS

- A. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

3.7 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
 - 2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
- B. Drain piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 46 00