New York State
Parks, Recreation and
Historic Preservation

Agency 1290000

PROJECT MANUAL

TA-JJ-2023-001
JOHN JAY HOMESTEAD: SITE AND BUILDING ENHANCEMENTS
JOHN JAY HOMESTEAD STATE HISTORIC SITE

BID PROPOSALS FOR THE FOLLOWING CONTRACT(S):
D006292 GENERAL CONTRACT
VOLUME 2 of 6

Are Due via email at:
12:30 PM
on
October 8, 2024

Bid proposals will be opened exclusively via Webex at:
1:00 PM
on
October 8, 2024

Webex Link at attend:
https://meetny.webex.com/meetny/j.php?MTID=m40b9689c6ed92a60ec352816a046e233

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TECHNICAL SPECIFICATIONS VOLUME 2 OF 3

for

JOHN JAY HOMESTEAD
SITE AND BUILDLING ENHANCEMENTS

John Jay Homestead
400 Jay Street
Katonah, New York

Prepared for:

New York State Office of Parks, Recreation and Historic Preservation
Taconic Region

by:

Beyer Blinder Belle Architects & Planners LLP
New York, NY

TA-JJ-2023-001

10 JULY, 2024

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END OF TABLE OF CONTENTS

ABBREVIATIONS

Parks	New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP)	Division 1
BBB	Beyer Blinder Belle, Architects & Planners, LLP	Architect
TT	Thornton Tomasetti	Structure Engineering
LFG	Landmark Facilities Group	MEP / IT / FP Engineering
CHA	CHA Consulting, Inc.	Civil Engineering
RHI	Rhodeside Harwell Landscape Architecture	Landscape Architect
HLB	HLB Lighting	Lighting Engineering
LVCK	LVCK – A Beyer Blinder Belle Studio	Signage
Matrix	Matrix New World Engineering	Hazardous Materials

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SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece cast brass or split-casting brass with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished brass finish.
d. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished brass finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished brass finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-casting, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: Split floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections
8. ASME B31.9 for building services piping valves.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

F. Valve Actuator Type:
   1. Hand Lever: For quarter-turn valves smaller than NPS 4.

G. Valves in Insulated Piping:

   1. Provide 2-inch extended neck stems.
   2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
   3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRASS BALL VALVES

A. Brass Ball Valves, One Piece, Threaded Ends:
   1. Standard: MSS SP-110, MSS SP-145.
   2. CWP Rating: 400 psig.
   3. Body Design: One piece.
   4. Body Material: Forged brass or bronze.
   5. Ends: Threaded.
   6. Seats: PTFE.
   7. Stem: Brass or stainless steel.
   8. Ball: Chrome-plated brass or stainless steel.
   9. Port: Reduced.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, One Piece with Bronze Trim, Threaded Ends:
   1. Standard: MSS SP-110; MSS SP-145.
   2. CWP Rating: 400 psig.
   3. Body Design: One piece.
   4. Body Material: Bronze.
   5. Ends: Threaded.
   6. Seats: PTFE.
   7. Stem: Bronze.
   8. Ball: Chrome-plated brass.
   9. Port: Reduced.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

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

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

C. Locate valves for easy access.

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

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags:.

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

H. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Brass ball valve, one piece. Provide with threaded or press-connection-joint ends.

2. Bronze ball valve, one piece with bronze trim. Provide with threaded or press-connection-joint ends.

END OF SECTION 220523.12

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Pipe-positioning systems.
6. Equipment supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

B. Copper Pipe and Tube Hangers:

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psig ASTM C552, Type II cellular glass with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 EQUIPMENT SUPPORTS

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

2.6 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

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

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

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

F. 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.

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.

I. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

5. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

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

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 ADJUSTING

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

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

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.7 HANGER AND SUPPORT SCHEDULE

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

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

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

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 and metal trapeze pipe hangers and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

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

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
2. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. C-Clamps (MSS Type 23): For structural shapes.

2. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

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

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 220529

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SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated.

1.3 QUALITY ASSURANCE

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

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.4 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.5 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
1. Preformed Pipe Insulation: Type II, Class 1, unfaced.
2. Preformed Pipe Insulation: Type II, Class 2, with factory-applied ASJ jacket.
3. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

E. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I for tubular materials.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
2. Wet Flash Point: Below 0 deg F.
3. Service Temperature Range: 40 to 200 deg F.
4. Color: Black.

D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: 0 to plus 180 deg F.

2.5 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
1. Permanently flexible, elastomeric sealant.
2. Service Temperature Range: Minus 58 to plus 176 deg F.
3. Color: White or gray.

C. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
1. Fire- and water-resistant, flexible, elastomeric sealant.
2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: White.

2.6 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 C1136, Type I.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.8 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy.

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers,:
1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

E. Install 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. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the contract documents.

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 attached to structure with vapor-barrier mastic.

3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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, but not to the extent of creating wrinkles or areas of compression in the insulation.
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. Install 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. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with 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 pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation.

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 in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.3 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 Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall 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 wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.

4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Engage a qualified testing agency to perform tests and inspections.

C. All insulation applications will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 PIPING INSULATION SCHEDULE, GENERAL

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

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

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

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/4 and Larger: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 and Larger: Insulation shall be one of the following:

a. Flexible Elastomeric: 1 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Flexible Elastomeric: 1/2 inch thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

END OF SECTION 220719

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SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Work Included: Provide Domestic water piping in accordance with the Contract Documents." The "General Conditions Governing All Contracts" shall apply to all work under the contract. The work of this section shall include, but not be limited to, the following:

B. Section Includes:

1. Aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.3 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.
4. Flexible connectors.
5. Escutcheons.
6. Sleeves and sleeve seals.
7. Water penetration systems.

B. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Domestic water piping.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. 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.
5. Copper Pressure-Seal-Joint Fittings:

    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) Elkhart Products Corporation; Industrial Division.
        2) NIBCO INC.
        3) Viega; Plumbing and Heating Systems.

    b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
    c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

6. Copper-Tube Extruded-Tee Connections:

    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) T-DRILL Industries Inc.

    b. Description: Tee formed in copper tube according to ASTM F 2014.

2.3 PIPING JOINING MATERIALS

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

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

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 or approved equal:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.
    d. Hart Industries International, Inc.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    f. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

    a. Pressure Rating: 150 psig (1035 kPa) at 180 deg F (82 deg C).
    b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or approved equal:

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Factory-fabricated, bolted, companion-flange assembly.
    b. Pressure Rating: 175 psig (1200 kPa) minimum.
    c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric 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 or approved equal:

    a. Calpico, Inc.
    b. Lochinvar Corporation.

2. Description:

a. Galvanized-steel coupling.
b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
c. End Connections: Female threaded.
d. Lining: Inert and noncorrosive, thermoplastic.

E. Dielectric Nipples:

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 or approved equal:

a. Perfection Corporation; a subsidiary of American Meter Company.
b. Precision Plumbing Products, Inc.
c. Victaulic Company.

2. Description:

a. Electroplated steel nipple complying with ASTM F 1545.
b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
c. End Connections: Male threaded or grooved.
d. Lining: Inert and noncorrosive, propylene.

2.5 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated or rough-brass finish with setscrews.

C. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.

D. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.

E. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew or spring clips.

G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.6 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.7 SLEEVE SEALS

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 or approved equal:

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.

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

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

C. Install domestic water piping level and plumb.

D. Install seismic restraints on piping.

E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

F. 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.

G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

H. Install piping adjacent to equipment and specialties to allow service and maintenance.

I. Install piping to permit valve servicing.

J. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

K. Install piping free of sags and bends.

L. Install fittings for changes in direction and branch connections.

M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

3.2 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

G. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

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

3.3 VALVE INSTALLATION

A. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 (DN 50 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

3.6 HANGER AND SUPPORT INSTALLATION

A. Hangers and Supports for Plumbing Piping and Equipment.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.

E. Install supports for vertical copper tubing every 10 feet (3 m).

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.

G. Install supports for vertical steel piping every 15 feet (4.5 m).

H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. 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 (DN 65) and larger.

3.8 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.

4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with rough-brass finish.
5. Bare Piping in Equipment Rooms: One piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.9 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 7 Section "Joint Sealants" for joint sealants.

G. Seal space outside of sleeves in concrete slabs and walls with grout.

H. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

I. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.

    a. Extend sleeves 2 inches (50 mm) above finished floor level.
    b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:

    a. PVC pipe sleeves for pipes smaller than NPS 6 (DN 150).
    b. Galvanized-steel sheet sleeves for pipes NPS 6 (DN 150) and larger.
    c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Interior Concrete Walls:

    a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).

J. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 7 Section "Penetration Firestopping" for firestop materials and installations.

3.10 SLEEVE SEAL INSTALLATION

A. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 15 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by the City of New York.
2. During installation, notify the City of New York at least one day before inspection must be made. Perform tests specified below in presence of the City of New York:

    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 final inspection for the City of New York to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If the City of New York find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by the City of New York.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test

source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

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 for corrective action required.

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

E. Prepare test and inspection reports.

3.13 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
4. Remove and clean strainer screens. Close drain valves and replace drain plugs.
5. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.14 PIPING SCHEDULE

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

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

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); cast- or wrought-copper solder-joint fittings; and soldered joints.
3. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.
4. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper push-on-joint fittings; and push-on joints.

3.15 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller.
2. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

C. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:

1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

C. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.

    a. Available Manufacturers:

        1) ANACO.
        2) Fernco, Inc.
        3) Ideal Div.; Stant Corp.
        4) Mission Rubber Co.
        5) Tyler Pipe; Soil Pipe Div.

2. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

    a. Available Manufacturers:

        1) ANACO.
        2) Clamp-All Corp.
        3) Ideal Div.; Stant Corp.
        4) Mission Rubber Co.
        5) Tyler Pipe; Soil Pipe Div.

3. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

    a. Available Manufacturers:

        1) MG Piping Products Co.

2.5 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.

C. Pressure Fittings:

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

D. Grooved-Joint Systems:

1. Available Manufacturers:

a. Anvil International.
b. Star Pipe Products; Star Fittings Div.
c. Victaulic Company.
d. Ward Manufacturing, Inc.

2. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, galvanized, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, galvanized, ductile-iron casting; with dimensions matching steel pipe.
3. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.6 STAINLESS-STEEL PIPE AND FITTINGS

A. Pipe and Fittings: ASME A112.3.1, drainage pattern with socket and spigot ends.

B. Gaskets: Lip seals shaped to fit socket groove, with plastic backup ring.

1. Material: EPDM, unless NBR is indicated.

2.7 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Grooved-Joint Systems:

1. Available Manufacturers:

a. Victaulic Company.

2. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

D. Flanges: ASME 16.1, Class 125, cast iron.

2.8 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Available Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco, Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Co.
e. NDS, Inc.
f. Plastic Oddities, Inc.

2. Sleeve Materials:

a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Available Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Mission Rubber Co.

C. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Available Manufacturers:

a. EBAA Iron Sales, Inc.
b. Romac Industries, Inc.
c. Star Pipe Products; Star Fittings Div.

D. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Available Manufacturers:

    a. SIGMA Corp.

2.9 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
3. Steel pipe, drainage fittings, and threaded joints.
4. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
5. Copper DWV tube, copper drainage fittings, and soldered joints.

C. Aboveground, vent piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
3. Steel pipe, drainage fittings, and threaded joints.
4. Stainless-steel pipe and fittings gaskets, and gasketed joints.
5. Copper DWV tube, copper drainage fittings, and soldered joints.

    a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2 (DN 65 and DN 90): Hard copper tube, Type M (Type C); copper pressure fittings; and soldered joints.
6. Dissimilar Pipe-Material Couplings: Flexible, Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 (DN 40 and DN 50) shall be any of the following:

1. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
2. Steel pipe, pressure fittings, and threaded joints.

2.10 PIPING INSTALLATION

A. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

B. 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.

C. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

E. 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.

F. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

G. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

H. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

2.11 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

D. 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.

E. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

2.12 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 (DN 100): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.

K. Install supports for vertical stainless-steel piping every 10 feet (3 m).

L. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.

M. Install supports for vertical copper tubing every 10 feet (3 m).

2.13 CONNECTIONS

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

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. 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 (DN 65) and larger.

2.14 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). 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 (250 Pa). 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.

2.15 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

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sump pumps.
2. Sump-pump basins and basin covers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Sump Pumps:
1. Description: Factory-assembled and -tested sump-pump unit.
2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
4. Impeller: Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron ASTM A532/A532M, abrasion-resistant cast iron and ASTM B584, cast bronze, semiopen design for clear wastewater handling, and keyed and secured to shaft.
5. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
6. Seal: Mechanical.

7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

    a. Motor Housing Fluid: Air.

8. Controls:

    a. Enclosure: NEMA 250, Type 1.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.

9. Control-Interface Features:

    a. Remote Alarm Contacts: For remote alarm interface.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

        1) On-off status of pump.
        2) Alarm status.

2.3 SUMP-PUMP BASINS AND BASIN COVERS

A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.

1. Material: Polyethylene.
2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors"

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.2 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 221429

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SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Commercial, electric, storage, domestic-water heaters.
2. Commercial, light-duty, storage, electric, domestic-water heaters.
3. Thermostat-control, electric, tankless, domestic-water heaters.
4. Domestic-water heater accessories.

1.2 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of commercial and tankless, electric, domestic-water heater.

B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Sample warranty.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: Five years.
2) Controls and Other Components: Five years.

b. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:

1) Storage Tank: Five years.
2) Controls and Other Components: Three years.

c. Electric, Tankless, Domestic-Water Heaters: Five year(s).
d. Expansion Tanks: Five years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:
1. Standard: UL 1453.
2. Storage-Tank Construction: Non-ASME-code, steel vertical arrangement.

a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

1) NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.
2) NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.

b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed, Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal with hose-end connection.
c. Insulation: Comply with ASHRAE/IES 90.1.
d. Jacket: Steel with enameled finish or high-impact composite material.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
f. Temperature Control: Adjustable thermostat.
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving

capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.

B. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
1. Standard: UL 174.
2. Storage-Tank Construction: Steel, vertical arrangement.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed, Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal with hose-end connection.
d. Insulation: Comply with ASHRAE/IES 90.1.
e. Jacket: Steel with enameled finish or high-impact composite material.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Heating Elements: Electric, screw-in immersion type.
h. Temperature Control: Adjustable thermostat.
i. Safety Control: High-temperature-limit cutoff device or system.
j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction with legs for off-floor installation.

2.3 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Flow-Control, Electric, Tankless, Domestic-Water Heaters:
1. Standard: UL 499 for electric, tankless, (domestic-water-heater) heating appliance.
2. Construction: Copper piping or tubing complying with NSF 61 and NSF 372 barrier materials for potable water, without storage capacity.

a. Connections: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Heating Element: Resistance heating system.
d. Temperature Control: Flow-control fitting.
e. Safety Control: High-temperature-limit cutoff device or system.
f. Jacket: Aluminum or steel with enameled finish or plastic.

3. Support: Bracket for wall mounting.

2.4 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:
   1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   2. Construction:

      a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Air-Charging Valve: Factory installed.

   3. Capacity and Characteristics:

      a. Working-Pressure Rating: 100 psig.

B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.

D. Heat-Trap Fittings: ASHRAE/IES 90.1.

E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig-maximum outlet pressure unless otherwise indicated.

F. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.

G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

I. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

J. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches above the floor.

K. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 18 inches above floor on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

C. Install electric, domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping,"

D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Installpressure relief valves in water piping for electric, domestic-water heaters without storage. Extend domestic-water heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains.

G. Install thermometers on outlet piping of electric, domestic-water heaters.

H. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

I. Fill electric, domestic-water heaters with water.

J. Charge domestic-water expansion tanks with air to required system pressure.

K. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

L. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections.

D. 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 operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 223300

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor-mounted, bottom-outlet water closets.
2. Wall-mounted water closets.
3. Flushometer valves.
4. Toilet seats.
5. Supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Comply with ASME A112.19.2/CSA B45.1 for water closets.
2. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets and tanks.
3. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.
4. Comply with IAMPO/ANSI Z124.5 for water-closet (toilet) seats.
5. Comply with ASME A112.6.1M for water-closet supports.
6. Comply with ICC A117.1 for ADA-compliant water closets.
7. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous china water closets to sanitary drainage systems.
8. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous china water closets to sanitary drainage systems.

2.2 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets - Floor Mounted, Bottom Outlet, Top Spud: .
   1. Bowl:

      a. Material: Vitreous china.
      b. Type: Siphon jet.
      c. Style: Flushometer valve.
      d. Height: ADA compliant.
      e. Rim Contour: Elongated.
      f. Water Consumption: 1.28 gal. per flush.
      g. Spud Size and Location: NPS 1-1/2; top.
      h. Color: White.

   2. Flushometer Valve: See fixture schedules.
   3. Toilet Seat: see fixture schedules

B. Water Closets - Floor Mounted, Bottom Outlet, Close-Coupled Flushometer Tank: see fixture schedules .
   1. Bowl:

      a. Material: Vitreous china.
      b. Type: Siphon jet.
      c. Style: Flushometer tank, pressure assisted.
      d. Height: ADA compliant.
      e. Rim Contour: Elongated.
      f. Water Consumption: 1.28 gal. per flush.
      g. Color: White.

   2. Toilet Seat: see fixture schedules.

2.3 WALL-MOUNTED WATER CLOSETS

A. Water Closets - Wall Mounted, Top Spud: see fixture schedules.
   1. Bowl:

      a. Material: Vitreous china.
      b. Type: Siphon jet.
      c. Style: Flushometer valve.
      d. Mounting Height: ADA compliant.
      e. Rim Contour: Elongated.
      f. Water Consumption: 1.28 gal. per flush.
      g. Spud Size and Location: NPS 1-1/2; top.
      h. Color: White.

   2. Flushometer Valve: see fixture schedules
   3. Toilet Seat: see fixture schedules
   4. Support: see fixture schedules .

B. Water Closets - Wall Mounted, Back Outlet, Close-Coupled Flushometer Tank: see fixture schedules .
   1. Bowl:

      a. Material: Vitreous china.
      b. Type: Siphon jet.
      c. Style: Flushometer tank, pressure assisted.
      d. Height: ADA compliant.
      e. Rim Contour: Elongated.
      f. Water Consumption: 1.28 gal. per flush.
      g. Color: White.

   2. Toilet Seat: see fixture schedules
   3. Support: Water-closet carrier.

2.4 FLUSHOMETER VALVES

A. Flushometer Valves - Diaphragm, Lever Handle: see fixture schedules.
   1. Minimum Pressure Rating: 125 psig.
   2. Features: Include integral check stop and backflow-prevention device.
   3. Material: Brass body with corrosion-resistant components.
   4. Style: Exposed.
   5. Flushometer-Valve Finish: Chrome-plated.
   6. Handle Finish: Chrome-plated.
   7. Consumption: 1.28 gal. per flush.
   8. Minimum Inlet: NPS 1.
   9. Minimum Outlet: NPS 1-1/4.

2.5 TOILET SEATS

A. Toilet Seats: .
   1. Material: Plastic.
   2. Type: Commercial (Heavy duty).
   3. Shape: Elongated rim, open front.
   4. Hinge: Check.
   5. Hinge Material: Noncorroding metal.
   6. Seat Cover: Required.
   7. Color: White.
   8. Surface Treatment: Antimicrobial.

2.6 SUPPORTS

A. Water-Closet Carrier:
   1. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.

B. Examine walls and floors for suitable conditions where water closets will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Water-Closet Installation:

1. Install level and plumb.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
5. Measure support height installation from finished floor, not structural floor.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations easily reachable for people with disabilities.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 PIPING CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

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SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vitreous-china, counter-mounted lavatories.
2. Vitreous-china, wall-mounted lavatories.
3. Precast GFRC, wall-mounted lavatories.
4. Precast GFRC, freestanding lavatories.
5. Manually operated lavatory faucets.
6. Automatically operated lavatory faucets.
7. Supply fittings.
8. Waste fittings.
9. Lavatory supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES

A. Lavatory - Self-Rimming,, Vitreous China, Counter Mounted: see fixture schedules
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: Self-rimming for above-counter mounting.
c.

2. Faucet: see fixture schedules

B. Lavatory - Oval, Vitreous China, Undercounter Mounted: see fixture schedules
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.

b. Type: For undercounter mounting.
c. Mounting Material: Sealant and undercounter mounting kit.

2. Faucet: see fixture schedules .

2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory - Rectangular, Vitreous China, Wall Mounted, with Back:
1. Fixture: see fixture schedules

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.
c. Mounting Material: Chair carrier.

2. Faucet: see fixture schedules
3. Support: see fixture schedules].
4. Lavatory Mounting Height: see fixture schedules

B. Lavatory - Ledge Back, Rectangular, Vitreous China, Wall Mounted
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.
c. Mounting Material: Chair carrier.

2. Faucet: see fixture schedules.
3. Support: see fixture schedules .
4. Lavatory Mounting Height: see fixture schedules

2.3 MANUALLY OPERATED LAVATORY FAUCETS

A. Lavatory faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372, or be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI) accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. Lavatory Faucets - Manual Type: Single-control mixing, commercial,.
1. Standard: ASME A112.18.1/CSA B125.1.
2. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
3. Maximum Flow Rate: 0.5 gpm.
4. Maximum Flow: 0.25 gal. per metering cycle.
5. Mounting Type:
6. Valve Handle(s):

2.4 AUTOMATICALLY OPERATED LAVATORY FAUCETS

A. Lavatory faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61/NSF 372, or be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI) accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. Lavatory Faucets - Automatic Type: Hardwired Electronic Sensor Operated, Mixing,:
   1. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
   2. 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.
   3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
   4. Body Type: Single hole.
   5. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
   6. Finish: see fixture schedules [.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

   1. Size: NPS 1-1/2 by NPS 1-1/4.
   2. Material:

      a. Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

b. Stainless steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless steel tube to wall; and stainless steel wall flange.

2.7 LAVATORY SUPPORTS

A. Lavatory Carrier:
1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lavatories level and plumb in accordance with roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, in accordance with ICC A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Indicate on Drawings those lavatories that are required to be accessible.

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.2 PIPING CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

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SECTION 224713 - DRINKING FOUNTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Drinking fountains.
2. Bottle filling stations.
3. Supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of drinking fountain and bottle filling station.

B. Shop Drawings:

1. Include diagrams for power wiring.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Drinking fountains and bottle filling stations intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
2. Comply with NSF 42 and NSF 53 for water filters for drinking fountains and bottle filling stations.
3. Comply with ICC A117.1 for accessible drinking fountains and bottle filling stations.

2.2 DRINKING FOUNTAINS

A. Drinking Fountains - Surface Wall-Mounted, Bronze: .
1. Type: Vandal resistant.

2. Maximum Water Flow: 0.5 gpm.
3. Control: Push bar.
4. Supply: NPS 3/8 with shutoff valve.
5. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 chrome-plated brass P-trap and waste.
6. Filter: One or more water filters with capacity sized for unit peak flow rate.
7. Electrical Characteristics:

    a. Volts: 120 V ac.
    b. Phase: Single.
    c. Hertz: 60 Hz.

8. Support: Provide manufacturer's mounting plate and drinking fountain carrier.
9. Drinking Fountain Mounting Height: Standard.
10. Freeze-Resistant Supply Fittings: Through wall freeze-resistant shutoff and flow-control valve assembly.

B. Drinking Fountains - Surface Wall-Mounted, Stainless Steel: .
1. Type: Vandal resistant.

2. Maximum Water Flow: 0.5 gpm.
3. Control: Push bar.
4. Supply: NPS 3/8 with shutoff valve.
5. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 chrome-plated brass P-trap and waste.
6. Filter: One or more water filters with capacity sized for unit peak flow rate.
7. Electrical Characteristics:

    a. Volts: 120 V ac.
    b. Phase: Single.
    c. Hertz: 60 Hz.

8. Support: Provide manufacturer's mounting plate and drinking fountain carrier.
9. Drinking Fountain Mounting Height: Standard.

2.3 BOTTLE FILLING STATIONS

A. Bottle Filling Station - Surface Wall-Mounted, ABS/Stainless Steel Combination: .
1. Type: Vandal resistant and freeze resistant.
2. Cabinet: ABS/stainless steel combination.
3. Bottle Filler: Sensor activation, with 20-second automatic shutoff timer. Fill rate 0.5 to 1.5 gpm.
4. Drain: Grid type with NPS 1-1/4 tailpiece.
5. Supply: NPS 3/8 with shutoff valve.
6. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
7. Filter: One or more water filters complying with NSF 42 and NSF 53 and with capacity sized for peak flow rate.
8. Support: Provide manufacturer's mounting plate and drinking fountain carrier.
9. Bottle Filling Station Mounting Height: Standard.
10. Electrical Characteristics:

a. Volts: 120 V ac.
b. Phase: Single.
c. Hertz: 60 Hz.

2.4 SUPPORTS

A. Drinking Fountain Carrier:
1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Set pedestal drinking fountains and bottle filling stations on flat surface in accordance with manufacturer's written installation instructions.

C. Install recessed, drinking fountains and bottle filling stations secured to wood blocking in wall construction.

D. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping"

F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 PIPING CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball shutoff valve on water supply to each fixture. Install valve upstream from filter for drinking fountain. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping"

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ELECTRICAL CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplates to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplates to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

3.5 CLEANING

A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224713

SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Duct-thermometer mounting brackets.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Flowmeters.
8. Thermal-energy meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch and/or 5-inch nominal diameter.

C. Dial: Nonreflective aluminum Insert material with permanently etched scale markings and scales in deg F.

D. Connector Type(s): Union joint, adjustable angle rigid, back and rigid, bottom, with unified-inch screw threads.

E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

G. Window: Plain glass or plastic.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 7-inch or 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle, Back angle, or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Plastic; 7-inch or 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle, Back angle, or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum, Brass, or Stainless steel and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.

9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:

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

B. Heat-Transfer Medium: [Mixture of graphite and glycerin] <Insert material>.

2.5 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Liquid-filled, Sealed, Open-front, pressure relief Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch or 6-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal, Brass or Stainless steel.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch or 6-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

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

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Liquid-filled or Sealed type; cast aluminum or drawn steel metal; 4-1/2-inch or 6-inch nominal diameter with back flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or Stainless steel.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch or 6-inch nominal diameter with back flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

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

B. Siphons: Loop-shaped section of brass, stainless-steel or steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 FLOWMETERS

A. Pitot-Tube Flowmeters:

1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in gallons per minute.

    a. Design: Differential-pressure-type measurement for water.
    b. Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
    c. Minimum Pressure Rating: 150 psig.
    d. Minimum Temperature Rating: 250 deg F.

4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Integral Transformer: For low-voltage power connection.
6. Accuracy: Plus or minus 3 percent.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

B. Turbine Flowmeters:
1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute.

    a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for [gas] [oil] [steam] [water] <Insert fluid>.
    b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
    c. Minimum Pressure Rating: [150 psig] <Insert value>.
    d. Minimum Temperature Rating: [180 deg F] <Insert temperature>.

4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Accuracy: Plus or minus [1-1/2] <Insert number> percent.
6. Display: Shows rate of flow[, with register to indicate total volume in gallons].
7. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:
1. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.

    a. Design: Differential-pressure-type measurement for gas and/or water.
    b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
    c. Minimum Pressure Rating: 250 psig.
    d. Minimum Temperature Rating: 250 deg F.
    e. End Connections for NPS 2 and Smaller: Threaded.
    f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.

g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

4. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch-diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

5. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot hoses, with carrying case.

   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.

6. Display: Shows rate of flow.
7. Conversion Chart: Flow rate data compatible with sensor.
8. Operating Instructions: Include complete instructions with each flowmeter.

2.8 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:
   1. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
   2. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

      a. Design: Total thermal-energy measurement.
      b. Minimum Pressure Rating: 150 psig.
      c. Minimum Temperature Range: 40 to 250 deg F.

   3. Temperature Sensors: Insertion-type transducer.
   4. Indicator: Solid-state, integrating-type meter with integral battery pack; for wall mounting.

      a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
      b. Battery Pack: Five-year lithium battery.

   5. Accuracy: Plus or minus 1 percent.
   6. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
   7. Strainer: Full size of main line piping.
   8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each water source variable refrigerant flow unit.
2. Two inlets and two outlets of each hydronic heat exchanger.
3. Suction and discharge of each geothermal ground water pump.
4. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:

1. Inlet and outlet of each water source variable refrigerant flow unit
2. Suction and discharge of each geothermal ground water pump.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic geothermal supply and return loop shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct and/or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.

B. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each thermal-storage tank shall be[one of] the following:

1. Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.

3. Industrial-style, liquid-in-glass type.

D. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.

E. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.

B. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

C. Scale Range for Chilled-Water Piping: 0 to 150 deg F.

D. Scale Range for Condenser-Water Piping: 0 to 100 deg F.

E. Scale Range for Condenser-Water Piping: 0 to 150 deg F.

F. Scale Range for Condenser-Water Piping: 0 to 250 deg F.

G. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.

H. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.

I. Scale Range for Heating, Hot-Water Piping: 50 to 400 deg F.

J. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

K. Scale Range for Steam and Steam-Condensate Piping: 20 to 240 deg F.

L. Scale Range for Air Ducts: Minus 40 to plus 160 deg F.

M. Scale Range for Air Ducts: 0 to 100 deg F.

N. Scale Range for Air Ducts: 0 to 150 deg F.

O. Scale Range for Air Ducts: 20 to 240 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, remote-mounted, plastic case.

B. Pressure gages at inlet and outlet of each geothermal-water loop connection shall be one of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, remote-mounted, plastic case.

C. Pressure gages at suction and discharge of each pump shall be one of the following:

1. Sealed Solid-front, pressure-relief, direct-mounted, metal case.
2. Sealed, remote-mounted, plastic case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: [0 to 100 psi] [0 to 100 psi and 0 to 600 kPa].

B. Scale Range for Chilled-Water Piping: [0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa].

C. Scale Range for Chilled-Water Piping: [0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa].

D. Scale Range for Condenser-Water Piping: [0 to 100 psi] [0 to 100 psi and 0 to 600 kPa].

E. Scale Range for Condenser-Water Piping: [0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa].

F. Scale Range for Condenser-Water Piping: [0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa].

G. Scale Range for Heating, Hot-Water Piping: [0 to 100 psi] [0 to 100 psi and 0 to 600 kPa].

H. Scale Range for Heating, Hot-Water Piping: [0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa].

I. Scale Range for Heating, Hot-Water Piping: [0 to 300 psi] [0 to 300 psi and 0 to 2500 kPa].

J. Scale Range for Steam Piping: [0 to 100 psi] [0 to 100 psi and 0 to 600 kPa].

K. Scale Range for Steam Piping: [0 to 160 psi] [0 to 160 psi and 0 to 1100 kPa].

L. Scale Range for Steam Piping: [0 to 200 psi] [0 to 200 psi and 0 to 1400 kPa].

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: [Pitot-tube] [Turbine] [Venturi] type.

B. Flowmeters for Condenser-Water Piping: [Pitot-tube] [Turbine] [Venturi] type.

C. Flowmeters for Heating, Hot-Water Piping: [Pitot-tube] [Turbine] [Venturi] type.

D. Flowmeters for Steam and Steam-Condensate Piping: [Turbine] [Venturi] type.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters: Impeller-turbine type.

END OF SECTION 230519

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SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Bronze ball valves.
3. Stainless steel ball valves.
4. High-performance butterfly valves.
5. Bronze swing check valves.
6. Stainless steel swing check valves.
7. Bronze gate valves.
8. Stainless steel gate valves.

B. Related Sections:

1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every plug valves, for each size square plug-valve head.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

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

a. American Valve, Inc.
b. Cincinnati Valve Co.
c. Crane Co.; Crane Valve Group; Crane Valves.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Div.
f. Grinnell Corporation.
g. Hammond Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:

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

    a. American Valve, Inc.
    b. Cincinnati Valve Co.
    c. Crane Co.; Crane Valve Group; Crane Valves.
    d. Crane Co.; Crane Valve Group; Jenkins Valves.
    e. Crane Co.; Crane Valve Group; Stockham Div.
    f. Grinnell Corporation.
    g. Hammond Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.

2. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: PTFE or TFE.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron.

C. Class 150, Bronze Angle Valves with Bronze Disc:

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

    a. American Valve, Inc.
    b. Cincinnati Valve Co.
    c. Crane Co.; Crane Valve Group; Crane Valves.
    d. Crane Co.; Crane Valve Group; Jenkins Valves.
    e. Crane Co.; Crane Valve Group; Stockham Div.
    f. Grinnell Corporation.
    g. Hammond Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.

2. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem and Disc: Bronze.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron.

D. Class 150, Bronze Angle Valves with Nonmetallic Disc:

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

a. American Valve, Inc.
b. Cincinnati Valve Co.
c. Crane Co.; Crane Valve Group; Crane Valves.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Div.
f. Grinnell Corporation.
g. Hammond Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

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

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Crane Co.; Crane Valve Group; Crane Valves.
d. Hammond Valve.
e. Lance Valves; a division of Advanced Thermal Systems, Inc.
f. Legend Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. .

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.

d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Lance Valves; a division of Advanced Thermal Systems, Inc.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 IRON BALL VALVES

A. Class 150, Iron Ball Valves:

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

a. American Valve, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Kitz Corporation.
d. Sure Flow Equipment Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-72.

b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

2.5 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.
n. .

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.

b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.6 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

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

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.

c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.

e. Ends: Threaded.
f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

2.7 STAINLESS STEEL SWING CHECK VALVES

A. Class 150, Stainless Steel Swing Check Valves with Metal Seats:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Legend Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Red-White Valve Corporation.
k. Sure Flow Equipment Inc.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.

d. Body Design: Clear or full waterway.
e. Body Material: ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548, cast steel with bolted bonnet.
f. Ends: Flanged.
g. Trim: Stainless steel.
h. Gasket: Asbestos free.

B. Class 250, Stainless Steel Swing Check Valves with Metal Seats:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548 cast steel with bolted bonnet.
f. Ends: Flanged.
g. Trim: Stainless Steel.
h. Gasket: Asbestos free.

2.8 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

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

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.

i. Powell Valves.
j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded[**or solder joint**].
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

B. Class 125, RS Bronze Gate Valves:

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

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

C. Class 150, NRS Bronze Gate Valves:

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

a. Hammond Valve.
b. Kitz Corporation.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Powell Valves.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
h. .

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

D. Class 150, RS Bronze Gate Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.9 STAINLESS STEEL GATE VALVES

A. Class 150, NRS, Stainless Steel Gate Valves:

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

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Crane Co.; Crane Valve Group; Stockham Division.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Kitz Corporation.
    g. Legend Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.
    j. Powell Valves.
    k. Red-White Valve Corporation.
    l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    m. Zy-Tech Global Industries, Inc.

2. Description:

    a. Standard: MSS SP-81, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
    c. NPS 14 to NPS 24, CWP Rating: 150 psig.
    d. Body Material: ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548, cast steel with bolted bonnet.
    e. Ends: Flanged.
    f. Trim: Stainless Steel.
    g. Disc: Solid wedge.
    h. Packing and Gasket: Asbestos free.

B. Class 150, OS&Y, Stainless Steel Gate Valves:

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

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Crane Co.; Crane Valve Group; Jenkins Valves.
    c. Crane Co.; Crane Valve Group; Stockham Division.
    d. Flo Fab Inc.
    e. Hammond Valve.
    f. Kitz Corporation.
    g. Legend Valve.
    h. Milwaukee Valve Company.
    i. NIBCO INC.
    j. Powell Valves.
    k. Red-White Valve Corporation.
    l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    m. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-81, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548, stainless steel with bolted bonnet.
e. Ends: Flanged.
f. Trim: Stainless Steel.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, NRS, Stainless Steel Gate Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. NIBCO INC.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-81, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.

d. Body Material: ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A53; ASTM A106; ASTM A234; ASTM A395; ASTM A420; ASTM A536; ASTM F1476; ASTM F1548, cast steel with bolted bonnet.
e. Ends: Flanged.
f. Trim: Stainless steel.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.3 VALVE INSTALLATION

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

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

3.4 ADJUSTING

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

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.

6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.6 GEOTHERMAL LOOP VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Angle Valves: Class 150, bronze disc.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, RS.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Stainless Steel Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
3. High-Performance Butterfly Valves: Class 150, single flange.
4. Stainless Steel Swing Check Valves: Class 250, metal seats.
5. Stainless Steel Gate Valves: Class 250, OS&Y.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Equipment supports.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for 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.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Flex-Strut Inc.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut Corporation; Tyco International, Ltd.
    g. Wesanco, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Electroplated zinc or Hot-dipped galvanized.

B. Non-MFMA Manufacturer Metal Framing Systems:

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

    a. Anvil International; a subsidiary of Mueller Water Products Inc.
    b. Empire Industries, Inc.
    c. ERICO International Corporation.
    d. Haydon Corporation; H-Strut Division.
    e. NIBCO INC.
    f. PHD Manufacturing, Inc.
    g. PHS Industries, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Zinc.

2.4 THERMAL-HANGER SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. 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.

2.6 EQUIPMENT SUPPORTS

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

2.7 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

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

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick 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.
2. Install mechanical-expansion anchors 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 attachments, inserts, bolts, rods, nuts, washers, and other accessories.

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

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

K. 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.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

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

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

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

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

3.6 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.

3.7 HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

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

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

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

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

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

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

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

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SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

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

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black

C. Background Color: White

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

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction. Duct service identification shall include air handler or fan that ducts are connected to and whether supply, return, etc.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 incheshigh.

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.

1. Stencil Material: Fiberboard or metal.
2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 PREPARATION

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

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Heating Water Piping:

   a. Background Color: Green
   b. Letter Color: White

2. Low-Pressure Steam Piping:

   a. Background Color: Green
   b. Letter Color: White

3. Steam Condensate Piping:

   a. Background Color: Green
   b. Letter Color: White

3.5 DUCT LABEL INSTALLATION

A. Locate stencils near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose

connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   a. Hot Water: 2 inches, round.
   b. Gas: 2 inches, round.
   c. Low-Pressure Steam: 2 inches, round.
   d. Steam Condensate: 2 inches, round.

2. Valve-Tag Color:
   a. Hot Water: Green.
   b. Gas: Yellow.
   c. Low-Pressure Steam: Yellow.
   d. Steam Condensate: Green.

3. Letter Color:
   a. Hot Water: White.
   b. Gas: Black.
   c. Low-Pressure Steam: Black.
   d. Steam Condensate: White.

3.7 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.

2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.

3. Testing, adjusting, and balancing of fuel oil systems for HVAC.
4. Testing, adjusting, and balancing of equipment.
5. Testing, adjusting, and balancing of existing HVAC systems and equipment.
6. Procedures for exhaust hoods.
7. Duct leakage tests verification.
8. Pipe leakage tests verification.
9. UFAD plenum leakage tests verification.
10. HVAC-control system verification.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

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

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.3 ACTION SUBMITTALS

A. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within [30] [60] [90] <Insert number> days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

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

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Qualifications, Certified by [NEBB] [or] [TABB]:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by [NEBB] [or] [TABB].
2. TAB Technician: Employee of the TAB specialist and certified by [NEBB] [or] [TABB].

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

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

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

1.6 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

F. Examine equipment performance data, including fan and pump curves.

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

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

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

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

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

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

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

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

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

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

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

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

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

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

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

1. Airside:

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

i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

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

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in [AABC's "National Standards for Total System Balance"] [ASHRAE 111] [NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"] and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

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)] [and] [metric (SI)] units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Pumps.
3. Fans and ventilators.
4. Unit heaters.
5. Water-to-water heat exchangers.
6. Condensing units.
7. Air-handling units.
8. Dedicated outdoor-air units.
9. Self-contained air conditioners.
10. Split-system air conditioners.
11. Variable-refrigerant-flow systems.
12. Heat pumps.
13. Fan coil units.
14. Unit ventilators.
15. Dehumidification units.

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' Record drawings 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.

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. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from [Architect] [Owner] [Construction Manager] [Commissioning Authority] for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
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 occurs. 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.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point 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.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.

c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, speed, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check expansion tank for proper setting.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.

6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

1. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow.

1. Measure total water flow.

a. Position valves for full flow through coils.
b. Measure flow by main flow meter, if installed.
c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

2. Measure pump TDH as follows:

a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.

3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

a. Re-measure and confirm that total flow is within design.

b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

    a. Measure differential pressure, and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

3.11 PROCEDURES FOR WATER-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record pressure drop.

D. Check and record settings and operation of safety and relief valves.

3.12 PROCEDURES FOR MOTORS

A. Motors [1/2] <Insert value> 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. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.

7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.13 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.14 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Calculated kilowatt at full load.
7. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. 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. Entering and leaving refrigerant pressure and temperatures.

3.16 PROCEDURES FOR EXHAUST HOODS

A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.

B. Makeup Air: Systems supplying source of makeup air to hoods shall be in operation during testing and balancing of exhaust hoods.

1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.

D. Canopy Hoods: Measure and record the following:

1. Pressure drop across hood.
2. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity.
3. Measure velocity across hood face and calculate hood airflow.

    a. Clearly indicate the direction of flow at each point of measurement.
    b. Measure velocity across opening on not less than [12-inch] <Insert dimension> centers. Record velocity at each measurement, and calculate average velocity.

4. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.

E. Laboratory Fume Hoods: Measure and record the following:

1. Pressure drop across hood.
2. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity. If hood is connected to exhaust duct distribution

through an exhaust device with integral airflow measurement, that reading may be used in lieu of a duct traverse.

3. Face velocity across open hood face and calculate hood airflow.

    a. Clearly indicate the direction of flow at each point of measurement.
    b. Measure velocity across opening on not less than [6-inch] <Insert dimension> centers. Record velocity at each measurement, and calculate average velocity.

4. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
5. ASHRAE 110 Testing: With room and laboratory fume hood operating at design conditions, perform an "as-installed" performance test of the laboratory fume hood in accordance with ASHRAE 110. Test [each] [indicate extent] laboratory fume hood and document the test results.

F. Kitchen Hoods:

1. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's instructions. Consult hood manufacturer to determine hood airflow using recorded information.
2. Type 2: Measure and record airflow by duct traverse.
3. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.

G. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.17 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.18 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.19 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.

2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
4. Check the refrigerant charge.
5. Check the condition of filters.
6. Check the condition of coils.
7. Check the operation of the drain pan and condensate-drain trap.
8. Check bearings and other lubricated parts for proper lubrication.
9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.

2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than [5] <Insert number> percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is [5] <Insert number> percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.21 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: [Plus or minus 10 percent] [Plus 10 percent or minus 5 percent] <Insert value>. If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: [Plus or minus 10 percent] [Plus 10 percent or minus 5 percent] <Insert value>. If design value is less than 100 cfm, within 10 cfm.
3. Heating-Water Flow Rate: [Plus or minus 5 percent] [Plus or minus 10 percent] [Plus 10 percent or minus 5 percent] <Insert value>. If design value is less than 10 gpm, within 10 percent.
4. Chilled-Water Flow Rate: [Plus or minus 5 percent] [Plus or minus 10 percent] [Plus 10 percent or minus 5 percent] <Insert value>. If design value is less than 10 gpm, within 10 percent.
5. Condenser-Water Flow Rate: [Plus or minus 5 percent] [Plus or minus 10 percent] [Plus 10 percent or minus 5 percent] <Insert value>.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.22 PROGRESS 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 system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare [weekly] [biweekly] [monthly] <Insert time interval> progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.23 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.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; 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 specialist.
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 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. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.
    g. [Variable-frequency controller] [Inlet vane] settings for variable-air-volume systems.
    h. Settings for pressure controller(s).
    i. Other system operating conditions that affect performance.

16. Test conditions for pump performance forms, including the following:

a. Variable-frequency controller settings for variable-flow hydronic systems.
b. Settings for pressure controller(s).
c. 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. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, 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. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.

i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.
n. [Vortex 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 in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.

f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

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.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

I. 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 in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.

h. Required net positive suction head in feet of head or psig.
i. Pump speed.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.24 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of [Architect] [Owner] [Construction Manager] [Commissioning Authority].

B. [Architect] [Owner] [Construction Manager] [Commissioning Authority] shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either [10] <Insert number> percent of the total measurements recorded or the extent of measurements that can be accomplished in [a normal 8-hour business day] <Insert value>.

C. 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."

D. If the number of "FAILED" measurements is greater than [10] [20] <Insert number> percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall 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. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.25 ADDITIONAL TESTS

A. Within [90] <Insert number> 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 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed outdoor air.
2. Indoor, exposed outdoor air.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

C. 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: 12 inches square.
2. Sheet Jacket Materials: 12 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. 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 and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, 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. 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 FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corp.; Commercial Board.
    b. Fibrex Insulations Inc.; FBX.
    c. Johns Manville; 800 Series Spin-Glas.
    d. Knauf Insulation; Insulation Board.
    e. Manson Insulation Inc.; AK Board.
    f. Owens Corning; Fiberglas 700 Series.

F. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Manson Insulation Inc.; AK Flex.
    e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

    a. Johns Manville; Super Firetemp M.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

    a. CertainTeed Corp.; FlameChek.
    b. Johns Manville; Firetemp Wrap.
    c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
    d. Thermal Ceramics; FireMaster Duct Wrap.
    e. 3M; Fire Barrier Wrap Products.
    f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
b. Vimasco Corporation; 713 and 714.

2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.

b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 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.

2.8 TAPES

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

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

a. ABI, Ideal Tape Division; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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

a. ABI, Ideal Tape Division; 488 AWF.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. 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.

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

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

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.

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

1) AGM Industries, Inc.; CHP-1.
2) GEMCO; Cupped Head Weld Pin.
3) Midwest Fasteners, Inc.; Cupped Head.
4) Nelson Stud Welding; CHP.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy.

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

a. C & F Wire.

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.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect’s intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect’s intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels),

it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 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.

3.3 PREPARATION

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

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. 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.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. 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.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. 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.

3.5 PENETRATIONS

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

B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping and fire-resistive joint sealers.

C. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates of duct and plenum surfaces.
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.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

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

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed outdoor air.
2. Indoor, exposed outdoor air.

B. Items Not Insulated:
1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Flexible connectors.
3. Vibration-control devices.
4. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
2. Factory applied FSK jacket.

B. Concealed, rectangular, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
   2. Factory applied FSK jacket.

C. Concealed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
   2. Factory applied FSK jacket.

D. Exposed, round and flat-oval, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
   2. Factory applied FSK jacket.
   3. Mineral-Fiber Pipe and Tank: 1-1/2 inches thick.

E. Exposed, rectangular, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
   2. Factory applied FSK jacket.

F. Exposed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 6-lb/cu. ft. nominal density.
   2. Factory applied FSK jacket.

END OF SECTION 230713

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SECTION 230719 - HVAC PIPING AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors.
2. Antifreeze piping, indoors.
3. Heating hot-water piping, indoors.
4. Air separators

B. Related Sections:

1. Section 230713 "Duct Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. Pittsburgh Corning Corporation; Foamglas.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Mineral or Glass-Fiber, Preformed Pipe Insulation:

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

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000-Degree Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.
    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.

c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

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

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
    d. Mon-Eco Industries, Inc.; 22-25.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

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

    a. Dow Corning Corporation; 739, Dow Silicone.
    b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Polyco VP Adhesive.

2.4 MASTICS

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

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

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
    b. Eagle Bridges - Marathon Industries; 550.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
    d. Mon-Eco Industries, Inc.; 55-50.
    e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
    c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide one of the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Pittsburgh Corning Corporation; Pittseal 444.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.7 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.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

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

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

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy or 0.062-inch soft-annealed, stainless steel.

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. C & F Wire.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 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.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install 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. 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. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. 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. Install 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. 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 pipe flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. 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.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.5 PENETRATIONS

A. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall 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 wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
3. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

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

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

3.10 PIPING INSULATION SCHEDULE, GENERAL

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

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

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

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick with factory applied ASJ and PVC fitting covers.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 1-1/4 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick, with factory applied ASJ and PVC fitting covers.

2. NPS 1-1/2 and Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick, with factory applied ASJ and PVC fitting covers.

C. Air Separators: Insulation shall be mineral-fiber, preformed pipe, type I or II, 2 inches thick with factory applied ASJ.

END OF SECTION 230719

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SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct digital control (DDC) system equipment and components for monitoring and controlling of HVAC, exclusive of instrumentation and control devices.

B. Related Requirements:
1. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
2. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.

J. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

K. HLC: Heavy load conditions.

L. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

M. I/P: Current to pneumatic.

N. LAN: Local area network.

O. LNS: LonWorks Network Services.

P. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.

10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

Q. 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.

R. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

S. Modbus TCP/IP: An open protocol for exchange of process data.

T. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

U. MTBF: Mean time between failures.

V. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

W. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

X. Peer to Peer: Networking architecture that treats all network stations as equal partners.

Y. POT: Portable operator's terminal.

Z. RAM: Random access memory.

AA. RF: Radio frequency.

BB. Router: Device connecting two or more networks at network layer.

CC. Server: Computer used to maintain system configuration, historical and programming database.

DD. TCP/IP: Transport control protocol/Internet protocol.

EE. UPS: Uninterruptible power supply.

FF. USB: Universal Serial Bus.

GG. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

HH. VAV: Variable air volume.

II. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    a. Servers.
    b. Gateways.
    c. Routers.
    d. Protocol analyzers.

e. DDC controllers.
f. Enclosures.
g. Electrical power devices.
h. UPS units.
i. Accessories.
j. Instruments.
k. Control dampers and actuators.
l. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity, and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
11. 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.

D. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

2. Include plans, elevations, sections, and mounting details where applicable.

3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:

    a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
    b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
    c. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
    d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
    e. Network communication cable and raceway routing.
    f. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:

    a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
    b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
    c. A graphic showing location of control I/O in proper relationship to HVAC system.
    d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
    e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
    f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
    g. Narrative sequence of operation.
    h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

    a. Each device connected to network with unique identification for each.
    b. Interconnection of each different network in DDC system.

c. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches, and transmitters.
d. Process signal tubing to sensors, switches, and transmitters.

11. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outpoints.
d. Operator workstation failure.
e. Server failure.
f. Gateway failure.
g. Network failure.
h. Controller failure.
i. Instrument failure.
j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.

1. Include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to do the following:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and databases on electronic media.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.6 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least five past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

    a. Product research and development.
    b. Product and application engineering.
    c. Product manufacturing, testing, and quality control.
    d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
    e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 50 miles of Project.
3. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrate past experience on five projects of similar complexity, scope, and value.
5. Demonstrate past experience of each person assigned to Project.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.7 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Perform warranty service during normal business hours and commence within 24 hours of Owner's warranty service request.
2. Warranty Period: Two year(s) from date of Substantial Completion.

    a. For Gateway: Two-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system consisting of peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

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.

2.2 WEB ACCESS

A. DDC system to be web based.

1. Web-Based Access to DDC System:

a. DDC system software based on server thin-client architecture, designed around open standards of web technology. DDC system server accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser is required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. Password-protected web access.

2.3 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. DDC system for monitoring and controlling of HVAC systems.

B. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system manages HVAC systems.
b. DDC system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system operates while unattended by an operator and through operator interaction.

e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.

C. DDC System Speed:

1. Response Time of Connected I/O:

a. Update AI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
b. Update BI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
c. AO points connected to DDC system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
d. BO point values connected to DDC system to respond to controller output commands within two second(s). Global commands to also comply with this requirement.

2. Display of Connected I/O:

a. Update and display analog point COV connected to DDC system at least every 10 seconds for use by operator.
b. Update and display binary point COV connected to DDC system at least every 10 seconds for use by operator.
c. Update and display alarms of analog and digital points connected to DDC system within 30 seconds of activation or change of state.
d. Update graphic display refresh within eight seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.

D. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
2. Local Storage:

a. Provide with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:

a. Provide application-based and web browser interfaces to configure, upload, download, and manage data and to service plan with storage adequate to store all data for term indicated. Cloud storage uses IT industry standard database platforms and is capable of functions described in "DDC Data Access" Paragraph.

E. DDC Data Access:

1. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

F. Future Expandability:

1. DDC system size is expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.
2. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.

G. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

   a. Thermal: Within 5 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

   a. Air: Within 5 percent of design flow rate.
   b. Air (Terminal Units): Within 5 Insert number percent of design flow rate.
   c. Water: Within 2 percent of design flow rate.

3. Moisture (Relative Humidity):

   a. Air: Within 2 percent RH.
   b. Space: Within 2 percent RH.
   c. Outdoor: Within 5 percent RH.

4. Level: Within 5 percent of reading.
5. Pressure:

   a. Air, Ducts and Equipment: 1 percent of instrument range.
   b. Water: Within 1 percent of instrument range.

6. Temperature, Dew Point:

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.
   c. Outdoor: Within 3 deg F.

7. Temperature, Dry Bulb:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 2 deg F.
    d. Condenser Water: Within 1 deg F.

8. Temperature, Wet Bulb:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 2 deg F.

H. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:

1. Current:

    a. Milliamperes: Nearest 1/100th of a milliampere.
    b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

    a. Electric Power:

        1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
        2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
        3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

3. Flow:

    a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
    b. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

4. Moisture (Relative Humidity):

    a. Relative Humidity (Percentage): Nearest 1 percent.

5. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.

6. Temperature:

    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest degree.

c. Space: Nearest 1/10th of a degree.
d. Chilled Water: Nearest 1/10th of a degree.
e. Condenser Water: Nearest 1/10th of a degree.
f. Heating Hot Water: Nearest degree.
g. Heat Recovery Runaround: Nearest 1/10th of a degree.
h. Steam: Nearest degree.

I. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.

2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 2.
b. Outdoors, Unprotected: Type 4.
c. Indoors, Heated with Filtered Ventilation: Type 1.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
e. Indoors, Heated and Air-Conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 12.
2) Air-Moving Equipment Rooms: Type 1.

J. Electric Power Quality:

1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-microssecond waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

K. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.4 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than two levels of LANs.

B. Provide dedicated DDC system LANs that are not shared with other building systems and tenant data and communication networks.

C. Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.

D. Configure architecture to minimize need to remove and replace existing network equipment for system expansion.

E. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.

F. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.

2.5 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:
1. Portable operator terminal with hardwired connection through LAN port.
2. Portable operator workstation with wireless connection through LAN router.
3. Mobile device and application with secured wireless connection through LAN router or cellular data service.
4. Remote connection through web access.

B. Make access to system, regardless of operator means used, transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.

D. Portable Workstations:
1. Able to communicate with any device located on any DDC system LAN.

2. Connect to DDC system Level 2 or Level 3 LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
3. Connect to system through a wireless router connected to Level 1 LAN.
4. Connect to system through a cellular broadband data service.
5. Portable workstation able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
6. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
7. Have dynamic graphic displays that are identical to desktop workstations.

E. Mobile Device (Tablet and Smart Phone):

1. Connect Owner-furnished mobile devices to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using dedicated application and secure web access.

F. Critical Alarm Reporting:

1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2. Send alarm notification to multiple recipients that are assigned for each alarm.
3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

G. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.6 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.

2. CTA-709.1-D.
3. TIA 485-A.
4. IP.
5. ISO/IEC/IEEE 8802-3, Ethernet.

2.7 NETWORK COMMUNICATION PROTOCOL

A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

B. Industry Standard Protocols:

1. Use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

   a. ASHRAE 135.
   b. CTA-709.1-D.
   c. Modbus Application Protocol Specification V1.1b3.

2. Operator workstations and network controllers are to communicate through ASHRAE 135 or CTA-709.1-D protocol.
3. Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
4. Provide portions of DDC system networks using CTA-709.1-D communication protocol as an open implementation of LonWorks technology using CTA-709.1-D communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
5. Provide portions of DDC system networks using Modbus Application Protocol Specification V1.1b3 communication protocol as an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b3.
6. Use gateways to connect networks and network devices with different protocols.

2.8 PORTABLE OPERATOR TERMINALS

A. Description: Handheld device with integral keypad or touch screen operator interface.

B. Display: Multiple lines of text display for use in operator interaction with DDC system.

C. Cable: Flexible coiling cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports, or instruments with an integral LAN port. As an alternative to hardwired connection, POTs may be accessible to DDC controllers through a wireless network connection.

D. Power POTs through network connection.

E. Connection of POTs to DDC system to not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

F. POTs to give operator ability to do the following:

1. Display and monitor BI point status.
2. Change BO point set point (on or off, open or closed).
3. Display and monitor analog point values.
4. Change analog control set points.
5. Command a setting of AO point.
6. Display and monitor I/O point in alarm.
7. Add a new or delete an existing I/O point.
8. Enable and disable I/O points, initiators, and programs.
9. Display and change time and date.
10. Display and change time schedules.
11. Display and change run-time counters and run-time limits.
12. Display and change time and event initiation.
13. Display and change control application and DDC parameters.
14. Display and change programmable offset values.
15. Access DDC controller initialization routines and diagnostics.
16. <**Insert requirements**>.

2.9 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32- or 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.

3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity and send to printer.
6. Security Access:

    a. Use password control for operator access to DDC system.
    b. Assign an alphanumeric password (field assignable) to each operator.
    c. Grant operators access to DDC system by entry of proper password.
    d. Use same operator password regardless of which computer or other operator interface means are used.
    e. Automatically update additions or changes made to passwords.
    f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
    g. Provide software with at least five access levels.
    h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
    i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.

7. Data Segregation:

    a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
    b. Include at least 32 segregation groups.
    c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
    d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.
    e. Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
    f. Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.

8. Operators able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.
    f. Enable and disable totalization for each point.
    g. Enable and disable trending for each point.
    h. Override control loop set points.
    i. Enter temporary override schedules.
    j. Define holiday schedules.

k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.
r. .

9. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disc files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.

10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. Provide dynamic points with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, command points directly from display using pointing device.

    a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
    b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
    c. Include a keyboard equivalent for those operators with that preference.

20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. Online context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.

    c. Available for Every Menu Item:

        1) Index items for each system menu item.

22. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.

    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
    b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:

        1) Define background screens.
        2) Define connecting lines and curves.
        3) Locate, orient, and size descriptive text.
        4) Define and display colors for all elements.
        5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
    1. Plan for building floor, including interstitial floors, and each roof level of each building, showing the following:

        a. Room layouts with room identification and name.
        b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
        c. Location and identification of each hardware point being controlled or monitored by DDC system.

    2. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
    3. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
    4. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.

E. Customizing Software:

    1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
    2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
    3. At a minimum, include the following modification capability:

        a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
        b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of printout of operator changes.
        c. System Configuration and Diagnostics; Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and

disable, assignment of command trace to points, and application programs and initiation of diagnostics.

d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.
e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.
f. Point related change capability is to include the following:

1) System and point enable and disable.
2) Run-time enable and disable.
3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
4) Assignment of alarm and warning limits.

g. Application program change capability is to include the following:

1) Enable and disable of software programs.
2) Programming changes.
3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and download capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:

a. Proportional control (P).
b. Proportional plus integral (PI).
c. Proportional plus integral plus derivative (PID).
d. Adaptive and intelligent self-learning control.

1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.
2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal to," "Not Equal to," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers.
2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display is to include the following:

    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.

5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send email alarm messages to designated operators.
7. Send email, page, text, and voice messages to designated operators for critical alarms.
8. Categorize and process alarms by class.

    a. Class 1:

        1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.

    b. Class 2:

        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.

    c. Class 3:

1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Setup each report so data content, format, interval, and date are operator definable.
3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Store reports and logs on servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

H. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

I. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

J. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Associate trends into groups, and setup a trend report for each group.
3. Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
6. When drive storage memory is full, overwrite oldest data with most recent data.
7. Make archived and real-time trend data available for viewing numerically and graphically by operators.

K. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.

1. Include each trend with interval, start time, and stop time.
2. Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on server hard drives.
3. Make data retrievable for use in spreadsheets and standard database programs.

L. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software is to be any of the following:

    a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.

        1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
        2) Make programming tools viewable in real time to show present values and logical results of each function block.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.10 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment

includes, but is not limited to, heat pumps, pumps, air handlers dehumidifiers and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.
2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.11 CTA-709.1-D NETWORK HARDWARE

A. Routers:

1. Network routers, including routers configured as repeaters, are to comply with requirements of CTA-709.1-D and include connection between two or more CTA-709.3 TP/FT-10 channels or between two or more CTA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
2. IP Routers:

a. Perform layer three routing of CTA-709.1-D packets over an IP network in accordance with CTA-852-C.
b. Include appropriate connection to IP network and connections to CTA-709.3 TP/FT-10 or TP/XF-1250 network.
c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CTA-852-C Configuration Server (for CTA-852-C configuration), but do not rely on these services for configuration.
d. Capable of manual configuration via a console RS-232 port.

B. Gateways:

1. Perform bidirectional protocol translation from one non-CTA-709.1-D protocol to CTA-709.1-D.

2. Incorporate a network connection to TP/FT-10 network in accordance with CTA-709.3 and a connection for non-CTA-709.1-D network.

2.12 DDC CONTROLLERS

A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.

C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware suitable for anticipated ambient conditions.
2. Controllers located in conditioned space rated for operation at 32 to 120 deg F.

F. Power and Noise Immunity:

1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.

2. Programmable Application Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:
1) Option to provide universal I/O to meet spare requirements.

H. General Requirements for CTA-709.1-D DDC Controllers:

1. LonMark certified.
2. Distinguishable and accessible switch, button, or pin, when pressed is to broadcast its 48-bit Node ID and Program ID over network.

3. TP/FT-10 transceiver in accordance with CTA-709.3 and connections for TP/FT-10 control network wiring.
4. TP/XF-1250 transceiver in accordance with CTA-709.3 and connections for TP/XF-1250 control network wiring.
5. Communicate using CTA-709.1-D protocol.
6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
7. Network communication through LNS network management and database standard for CTA-709.1-D network devices.
8. Locally powered, not powered through network connection.
9. Functionality required to support applications indicated including, but not limited to, the following:

    a. I/Os indicated and as required to support sequence of operation and application in which it is used. SNVTs to have meaningful names identifying the value represented by SNVT. Unless SNVT of an appropriate engineering type is unavailable, all network variables to be of SNVT with engineering units appropriate to value the variable represents.
    b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.

10. Programmable controllers comply with "LonMark Interoperability Guidelines" and have LonMark certification.

I. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

    a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
    b. Compatible with, and field configurable to, sensor and transmitters installed.
    c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
    d. Signal conditioning including transient rejection for each AI.
    e. Capable of being individually calibrated for zero and span.
    f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
    g. External conversion resistors are not permitted.

5. AOs:

a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
b. Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. Drift is to be not greater than 0.4 percent of range per year.
e. External conversion resistors are not permitted.

6. BIs:

a. Accept contact closures and ignore transients of less than 5 ms duration.
b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.

7. BOs:

a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
3) Minimum contact rating to be 1 A at 24 V ac.
4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.

b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs to be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.

2.13 NETWORK CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
4. Share data between networked controllers and other network devices.

5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Include network controllers with a real-time clock.
7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
8. Make controllers fully programmable.

B. Communication:

1. Network controllers communicate with other devices on DDC system Level 1 network.
2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to portable operator's workstation POT or mobile device.
2. Local Keypad and Display:

   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display requires a security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 72 hours.

2.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers that perform scheduling with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to portable operator's workstation POT or mobile device.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Protect use of keypad and display by security password.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.15 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and continued control functions without being connected to network.
2. Share data between networked controllers and other network devices.

B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.

C. Operator Interface: Equip controllers with a service communications port for connection to portable operator's workstation POT or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations or mobile devices.
2. Identify I/O points by up to 30-character point name and up to 16-character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Secure operator access using individual security passwords and user names.
2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
3. Record operator log-on and log-off attempts.
4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:

1. Weekly Schedule:

   a. Include separate schedules for each day of week.
   b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Place schedules on scheduling calendar with ability to repeated each year.
   c. Operator able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.

2. Include operator with a method of grouping together equipment based on function and location.
3. Include groups that may be for use in scheduling and other applications.

E. Binary Alarms:

1. Set each binary point to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Provide each analog object with both high and low alarm limits.
2. Include capability to automatically and manually disable alarming.

G. Alarm Reporting:

1. Include ability for operators to determine action to be taken in event of an alarm.
2. Route alarms to appropriate operator workstations based on time and other conditions.
3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

H. Remote Communication:

1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.

I. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

J. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

K. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Make controlled variable, set point, and PID gains operator-selectable.

e. Adaptive (automatic tuning).

L. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

M. Anti-Short Cycling:

1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

N. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

O. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. Assign a high run-time alarm, if required, by operator.

2.17 ENCLOSURES

A. General:

1. House each controller and associated control accessories in single enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Do not house more than one controller in single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch-high lettering.

13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

2.18 RELAYS

A. General-Purpose Relays:
1. NRTL listed.
2. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
3. SPDT, DPDT, or three-pole double-throw, as required by control application.
4. Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.
5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in apolycarbonate dust-tight cover.
7. Include LED indication and push-to-test button to test manual operation of relay without power on coil.
8. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Pickup Time: 15 ms or less.
d. Dropout Time: 10 ms or less.
e. Pull-in Voltage: 85 percent of rated voltage.
f. Dropout Voltage: 50 percent of nominal rated voltage.
g. Power Consumption: 2 VA or less.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.

10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Current Sensing Relays:
1. NRTL listed.
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from [**50**] <**Insert number**> to [**95**] <**Insert number**> percent of pickup current.
7. Visual indication of contact status.
8. Include current transformer, if required for application.
9. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, [**Type 1**] [**or**] [**Type 12**] enclosure for indoors applications and NEMA 250, [**Type 4**] [**or**] [**Type 4X**] for outdoor applications.

2.19 ELECTRICAL POWER DEVICES

A. Control Transformers:

1. Sizing Criteria: Size control transformers for total connected load, plus additional 25 percent of connected load for future spare capacity.
2. Transformer Minimum Capacity: 40 VA.
3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B. DC Power Supplies:
1. Description: Linear or switched, regulated power supplies with ac input to one or multiple dc output(s).

a. Include both line and load regulation to ensure stable output.
b. To protect both power supply and load, include power supply with an automatic current limiting circuit.

2. Features:

a. Connection: Plug-in style suitable for mating with standard 8-pin octal socket. Include power supply with mating mounting socket.
b. Housing: Enclose circuitry in a housing.
c. Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.
d. Mounting: DIN rail.
e. Visual status indicator.

3. Performance:

a. Input Voltage: Nominally 120 V ac, 60 Hz.
b. Output Voltage: Nominally 24 V dc with plus or minus 1 V dc adjustment.
c. Output Current: Minimum 100 mA.
d. Load Regulation: Within 0.1 percent.
e. Line Regulation: Within 0.05 percent.
f. Stability: Within 0.1 percent of rated volts after warmup period.
g. Ripple: 1 mV rms.

2.20 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire Size: Minimum 18 AWG.
2. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
5. Furnish on spools.

B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
4. Conductor Insulation Colors:

   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
7. Furnish on spools.

C. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Conductor Insulation Colors:

   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
7. Furnish on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Comply with following requirements for balanced twisted pair cable

a. Plenum rated.
b. Unique color that is different from other cables used on Project.

2.21 ACCESSORIES

A. Control Damper Blade Limit Switches:

1. Application: Sense positive open and/or closed position of damper blades.
2. NEMA 250,, oiltight construction. Install in instrument enclosure where required for additional environmental protection.
3. Arrange for mounting application, and to prevent "over-center" operation.

B. Manual Valves:

1. Brass Needle Valves:
   a. Pressure Rating: 150 psig.
   b. Temperature Rating: 250 deg F.
   c. Body: Brass.
   d. Seat: Brass.
   e. Handle: Aluminum, brass, or stainless steel T-bar handle.
   f. Connections: Include tubing connections.
   g. Applications: Copper and polyethylene pneumatic tubing.

2. Stainless Steel Needle Valves:
   a. Pressure Rating: 5000 psig.
   b. Temperature Rating: 450 deg F.
   c. Body: Type 316 stainless steel.
   d. Seat: Type 316 stainless steel.
   e. Packing: PTFE.
   f. Handle: Aluminum or stainless steel T-bar handle.
   g. Connections: Include tubing connections.
   h. Applications: Copper pneumatic tubing; copper and stainless steel process tubing.

3. Bronze Body Ball Valves:
   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Handle: Stainless steel with vinyl grip.
   k. Port: Full.

2.22 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Laminated acrylic or melamine plastic sign bearing unique identification.

    a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
3. Fastened with drive pins.
4. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tag Size: Minimum 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inchbeyond white border.

PART 3 - EXECUTION

3.1 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.

B. Communication Interface to Other Building Systems:

1. DDC system communicates with systems having communication interface.

3.2 PREINSTALLATION INTEGRATION TESTING

A. Perform the following pretesting of other systems and equipment integration with DDC system before field installation:

1. Test all communications in a controlled environment to ensure connectivity.
2. Load software and demonstrate functional compliance with each control sequence of operation indicated.
3. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:

    a. HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.
    b. Equipment faults and system recovery with fault annunciation.
    c. Analog and Boolean value alarming and annunciation.

4. Develop a method for testing interfaces before deployment.
5. Submit documentation supporting compliance upon request.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Fastening Hardware:

1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.4 INSTALLATION OF WORKSTATIONS

3.5 INSTALLATION OF POT

A. Install one POT(s).

B. Turn over POTs to Owner at Substantial Completion.

C. Install software on each POT and verify that software functions properly.

3.6 INSTALLATION OF SERVERS

A. Install server(s) at location(s) indicated on Drawings.

B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed server location in Shop Drawings.

C. Install software indicated on server(s) and verify that software functions properly.

D. Develop Project-specific graphics, trends, reports, logs, and historical database.

3.7 INSTALLATION OF GATEWAYS

A. Install gateways if required for DDC system communication interface requirements indicated.

1. Install gateway(s) required to suit indicated requirements.

B. Test gateways to verify that communication interface functions properly.

3.8 INSTALLATION OF ROUTERS

A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.

B. Test routers to verify that communication interface functions properly.

3.9 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G. Application-Specific Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in alocation that is easily accessible by operators.

3.10 INSTALLATION OF ENCLOSURES

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. Relays.
6. Accessories.
7. Instruments.
8. Actuators.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.
2. Install plastic caps on exposed cut edges of strut.

C. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.11 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.16 "Boxes and Covers for Electrical Systems" for electrical power raceways and boxes.

3.12 INSTALLATION OF IDENTIFICATION

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

B. Install unique instrument identification for each instrument connected to DDC controller.

C. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

D. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

E. Warning Labels and Signs:

1. Permanently attach to equipment that can be automatically started by DDC control system.
2. Locate where highly visible near power service entry points.

3.13 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Assign and document a MAC address unique to its network for every network device.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. MS/TP Networks: Assign from 00 to 64.

2. Network Numbering:

    a. Assign unique numbers to each new network.
    b. Provide ability for changing network number through device switches or operator interface.
    c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

    a. Assign unique device object identifier property numbers or device instances for each device network.
    b. Provide for future modification of device instance number by device switches or operator interface.
    c. LAN is to support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

    a. Device object name property field to support 32 minimum printable characters.
    b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

        1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
        2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."

5. Object Name Property Text for Other Than Device Objects:

    a. Object name property field is to support 32 minimum printable characters.
    b. Assign object name properties with plain-English names descriptive of application.

        1) Example 1: "Zone 1 Temperature."
        2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

    a. Assign object identifier property numbers according to [**Drawings**] [**or**] [**tables**] indicated.
    b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.14 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."

2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

    a. Clamp cable over jacket in a junction box.
    b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section 260533.13 "Conduits for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.15 INSTALLATION OF OPTICAL FIBER CABLE SYSTEMS

A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."

B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.16 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

E. Control Damper Checkout:
1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

F. Control Valve Checkout:
1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment are secure.
4. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
5. Verify that valve ball, disc, or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:

a. Sensing element type and proper material.
b. Length and insertion.

3.17 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.

F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.

H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

I. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

J. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

K. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

L. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.18 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase, and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to backup power source.
6. If applicable, verify that power conditioning units are installed.

B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.19 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify that operation is stable and accurate.
4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.

9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.20 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After review of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed Pretest Checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting, and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor, and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
26. Record Drawings are completed.

3.21 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.22 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, verify that maintenance service includes three months' full maintenance by DDC system manufacturer's authorized service representative. Include monthly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.23 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

1. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.24 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide not less than five days of training total.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.
    c. Break down total days of training into not more than two separate training classes.
    d. Schedule training so each training class is not less than one consecutive day(s).

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Provide staggered training schedule as requested by Owner.

D. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual presentations.
2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

E. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Use instructors who have provided not less than five years of instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

F. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

    a. Daily operators.
    b. Advanced operators.
    c. System managers and administrators.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

G. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

H. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.

4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

I. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading, and offline archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.
9. .

J. Video of Training Sessions:

1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
2. Stamp each recording file with training session number, session name, and date.
3. Provide Owner with two copies of digital files on cloud and flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923

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SECTION 230993.11 SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 GENERAL

1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B.

C. Related Requirements:

1. Section 230923 "DDC Systems for HVAC" for control equipment.

1.2 CONTROL SEQUENCES

A. OVERVIEW

1. The VRF Heat pump system includes an integral control system that activates the branch controller and heat pump module as needed. The BMS shall interface with the integrated controls via a thermostat module manufactured by the heat pump equipment manufacturer.
2. The VRF heat pump water source is to be provided with a flow switch that will be wired directly to each heat pump to prevent it from operating without water flow.

B. VRF Indoor Air Handlers

1. Fan Control
   a. When enabled through the control system, air handlers shall run 24 hours per day.
2. VRF Air Handler Cooling Mode
   a. Control system shall monitor the temperature and relative humidity sensors in each zone.
   b. Upon sensing a zone temperature above the cooling setpoint for that zone, the control system shall send a “cooling enable” signal to the integrated controller for the VRF system.
   c. The control system shall monitor the dry contacts on each heat pump that signal a call for water demand. Upon sensing a demand for ground loop water flow from either heat pump, the BMS shall open the source water isolation valve for the respective heat pump and energize the ground loop water circulating pump
   d. The VRF system integrated controller shall send signals to the heat pump branch controller and the water-source VRF Heat Pump module as needed to provide cooling at the indoor air handler.
3. VRF Air Handler Heating Mode
   a. Control system shall monitor the temperature and relative humidity sensors in each zone.

b. Upon sensing a zone temperature below the heating setpoint for that zone, the control system shall send a "heating enable" signal to the integrated controller for the VRF system.
c. The control system shall monitor the dry contacts on each heat pump that signal a call for water demand. Upon sensing a demand for ground loop water flow from either heat pump, the BMS shall open the source water isolation valve for the respective heat pump and energize the ground loop water circulating pump
d. The VRF system integrated controller shall send signals to the heat pump branch controller and the water-source VRF Heat Pump module as needed to provide heating at the indoor air handler

4. VRF Air Handler Dehumidification Mode
   a. Control system shall monitor the temperature and relative humidity sensors in each zone.
   b. Upon sensing a zone relative humidity above the dehumidification setpoint for that zone, the control system shall enable the dehumidifier for that zone.
5. DDC system graphic.
   a. DDC system on-off indication (operating or not operating).
   b. DDC system occupied/unoccupied mode.
   c. Outdoor-air-temperature indication.
   d. Supply-fan on-off indication (operating or not operating).
   e. Relative humidity indication.
   f. Relative humidity set point.
   g. Filter air-pressure-drop indication.
   h. Filter low-air-pressure drop set point.
   i. [Supply] [Discharge]-air-temperature indication.
   j. [Supply] [Discharge]-air-temperature set point.
   k. Space temperature indication.
   l. Space temperature set point.

C. VRF Heat Pump Module
   1. VRF system integrated controller shall enable and operate the VRF Heat Pump module.
D. Ground loop Circulating Pumps
   1. Enable/Disable
      a. Upon there being a call for heating or cooling from the heat pump, the control system shall energize the lead ground loop pump.
   2. Speed Control
      a. The control system shall monitor the ground loop differential pressure across the heat pumps and operate the pumps to maintain a minimum differential pressure of 10 psi.
   3. Operate pump(s) on lead-lag, alternating each startup.

a. Additional Circulating Pump(s): Energize pump(s) and maintain operation when differential pressure drops below 30 percent of specified pump head.

4. Circulating Pump(s) Failure Alarm: Signal alarm condition, if there is no pressure differential between supply and return piping.
5. DDC system graphic.
   a. DDC system status, on-off.
   b. Outdoor-air temperature.
   c. Room temperature.
   d. Circulating pump(s) on-off status (enabled or disabled).
   e. Circulating pump(s) on-off indication (operating or not operating).
   f. Additional circulating pump(s) pressure differential.
   g. Additional circulating pump(s) pressure differential set point.
   h. Additional circulating pump(s) on-off indication (operating or not operating).
   i. Circulating pump(s) alarm pressure differential.
   j. Circulating pump(s) alarm pressure differential set point.
   k. Alarm (circulating pump(s) failure).
   l. Circulating pump(s) speed pressure differential.
   m. Circulating pump(s) speed pressure differential set point.
   n. Circulating pump(s) speed.
   o. Source water supply temperature.
   p. Source water return temperature.

PART 2 PRODUCTS - Not applicable

PART 3 EXECUTION - Not applicable

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SECTION 232113.33 - GROUND-LOOP HEAT-PUMP PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes piping for vertical, direct-buried, ground-loop, heat-pump systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Startup performance results.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

A. HDPE Pipe: ASTM D3035.

B. Molded PE Fittings: ASTM D2683 or ASTM D3261, ASTM F1055 PE resin, socket, butt-fusion or electro-fusion type, made to match PE pipe dimensions and class.

C. U-Bend Assembly: Factory fabricated with embossed depth stamp every 36 inches from U-bend.

D. Ground-Loop, Heat-Pump Piping Minimum Working Pressure: 160 psig.

E. Ground-Loop, Heat-Pump Piping Operating Temperature: Between 23 and 104 deg F.

2.2 BOREHOLE BACKFILL

A. Seal Material: Bentonite clay with thermal conductivity greater than 1.07 Btu/h x sq. ft. x deg F according to ASTM D5334.

B. Permeability: Not more than 1 nm/s according to ASTM D5084

2.3 ANTIFREEZE SOLUTION

A. Propylene glycol with corrosion inhibitors and environmental stabilizer additives.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, warning tape, and backfilling are specified in Section 312000 "Earth Moving."

3.2 VERTICAL PIPING INSTALLATION

A. Install HDPE piping in boreholes according to ASTM D2774 or ASTM F645.

1. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D2657. Minimize number of joints.

B. Purge, flush, and pressure test piping before backfilling boreholes.

C. Completely fill the borehole from bottom to top with backfill material.

D. Install the header piping 4 to 6 inches deep and install the horizontal piping from the header to the boreholes.

E. Extend the horizontal piping and connect to ground-loop heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building ground-loop heat-pump piping systems are installed. Terminate piping with caps. Make connections to building ground-loop heat-pump piping systems when those systems are installed.

F. Backfill the horizontal piping and header trenches.

G. Fill the entire piping loop with water or antifreeze solution.

H. Maintain records of backfilling on-site.

I. Mark borehole locations, header pipes, and horizontal runs with metallic locator tape

J. Seal penetrations through building walls.

3.3 ANTIFREEZE SOLUTION FILL

A. Fill system with required quantity of propylene glycol and water to provide minus 10 deg F freezing temperature.

3.4 CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

A. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.

B. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating or 300 percent of system design pressure, whichever is more, allowing for static pressure of borehole depth.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig. Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
2. Maintain a minimum pipe velocity of 24 in./s for a minimum of 15 minutes to remove all air.

C. Prepare test and inspection reports.

END OF SECTION 232113.33

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Makeup-water piping.
2. Condensate-drain piping.
3. Blowdown-drain piping.
4. Air-vent piping.
5. Safety-valve-inlet and -outlet piping.
6. Chemical Treatment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
1. Pressure-seal fittings.
2. Propylene Glycol treatment.

1.4 INFORMATIONAL SUBMITTALS

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

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Makeup-Water Piping: 150 psig at 120 deg F.
2. Condensate-Drain Piping: 40 deg F.
3. Air-Vent Piping: 200 deg F.
4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 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 Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

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

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

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

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

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

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

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

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

G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

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

    a. A.Y. McDonald Mfg. Co.
    b. Capitol Manufacturing Company.
    c. Central Plastics Company.
    d. Hart Industries International, Inc.
    e. Jomar International, Ltd.
    f. Matco-Norca.
    g. Watts Regulator Co.
    h. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

2. Description:

    a. Standard: ASSE 1079.
    b. Pressure Rating: 175 psig minimum at 250 deg F.
    c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Matco-Norca.
    d. Watts Regulator Co.
    e. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

2. Description:

    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.
    c. Pressure Rating: 175 psig minimum at 250 deg F.
    d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

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

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Description:

    a. Nonconducting materials for field assembly of companion flanges.

b. Pressure Rating: 175 psig minimum at 250 deg F.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

a. Elster Perfection.
b. Grinnell Mechanical Products.
c. Matco-Norca.
d. Precision Plumbing Products, Inc.
e. Victaulic Company.

2. Description:

a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F 1545.
c. Pressure Rating: 175 psig minimum at 250 deg F.
d. End Connections: Male threaded
e. Lining: Inert and noncorrosive, propylene.

2.6 MAKE UP HYDRONIC AND CHEMICAL FEEDER

A. Description: 5-55-psig working pressure; 55-gal. capacity; with check valve, fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale, corrosion in piping and connected equipment, and from water freezing.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect’s intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 PIPING APPLICATIONS

A. Makeup-water piping installed aboveground shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

B. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

C. Condensate-Drain Piping: Type M or Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

E. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 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 to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

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

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

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

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

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

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

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

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

X. Install fire protection materials at each pipe penetration that meet or exceed the fire rated assembly.

3.4 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.

4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. 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.

G. Fiberglass 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.

H. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.6 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. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the branch pipe size indicated on drawings.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with calibrated balance valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 ppm.
    b. Molybdate: 200 to 300 ppm.
    c. Chromate: 200 to 300 ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
    e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

D. Fill systems that have antifreeze or glycol solutions with the following concentrations:
1. Geothermal-Water Piping: 30 percent propylene glycol.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

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SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Makeup-water piping.
2. Condensate-drain piping.
3. Air-vent piping.
4. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Makeup-Water Piping: 150 psig) at 120 deg F.
2. Condensate-Drain Piping: 40 deg F.
3. Air-Vent Piping: 200 deg F.
4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."Section 15112 "General-Duty Valves for HVAC Piping."

B. Bronze, Calibrated-Orifice, Balancing Valves:

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

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Nexus Valve, Inc.
    g. Taco.
    h. Tour & Andersson; available through Victaulic Company.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

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

    a. Armstrong Pumps, Inc.
    b. Bell & Gossett Domestic Pump.
    c. Flow Design Inc.
    d. Gerand Engineering Co.
    e. Griswold Controls.
    f. Nexus Valve, Inc.
    g. Taco.
    h. Tour & Andersson.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Conbraco Industries, Inc.
    e. Spence Engineering Company, Inc.
    f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Diaphragm-Operated Safety Valves: ASME labeled.

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Automatic Flow-Control Valves:

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

a. Flow Design Inc.
b. Griswold Controls.
c. Nexus Valve, Inc.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 250 deg F.

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.

e. Taco, Inc.

2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. Taco, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 240 deg F (116 deg C).

C. Expansion Tanks:

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.

4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
5. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- (20-mm-) diameter gage glass, and slotted-metal glass guard.

D. Bladder-Type Expansion Tanks:

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Taco, Inc.

2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Tangential-Type Air Separators:

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

    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett Domestic Pump.
    d. Taco, Inc.

2. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

F. In-Line Air Separators:

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

    a. AMTROL, Inc.
    b. Armstrong Products, Inc.
    c. Bell & Gossett Domestic Pump.

d. Taco, Inc.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

G. Air Purgers:

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

a. AMTROL, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump.
d. Taco, Inc.

2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
3. CWP Rating: 750 psig (5170 kPa).

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's

direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

D. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

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SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Separately coupled, base-mounted, end-suction centrifugal pumps.
   2. Automatic condensate pump units.

1.2 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. FKM: Fluoroelastomer polymer.

D. HI: Hydraulic Institute.

E. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump.

B. Shop Drawings: For each pump.

C. Delegated-Design Submittal: For each pump.

   1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

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

B. Seismic Qualification Data: Certificates, for pumps, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
   1. Component Importance Factor: 1.5.

2.2 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

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

   1. Armstrong Fluid Technology.
   2. ITT Corporation.
   3. Taco Comfort Solutions.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

   1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
   2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
   3. Pump Shaft: Type 316 stainless steel.
   4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket.
   5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
   6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.

H. Capacities and Characteristics:

1. Capacity: See drawings.
2. Total Dynamic Head: See drawings.
3. Maximum Operating Pressure: 250 psig.
4. Maximum Continuous Operating Temperature: 250 deg F.
5. Inlet and Outlet Size: See drawings.
6. Impeller Size: See drawings.
7. Motor Speed: See drawings.
8. Motor Horsepower: See drawings.
9. Electrical Characteristics:

a. Volts: See drawings.
b. Phase: See drawings.
c. Hertz: 60 Hz.
d. Full-Load Amperes: See drawings A.
e. Minimum Circuit Ampacity: See drawings A.
f. Maximum Overcurrent Protection: See drawings A.

2.3 AUTOMATIC CONDENSATE PUMP UNITS

A. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Collects and removes condensate from fan coil units, air handling units, condensing boilers, and similar components. Include factory- or field-installed check valve and 72-inch-minimum, electrical power cord with plug.

2.4 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 300-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch.
4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 300-psig pressure rating, cast-iron body, pump-discharge fitting.
3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
4. Brass valve disc with EPDM rubber seat.
5. Type 304 stainless steel valve stem.
6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
7. Brass gauge ports with integral check valve and orifice for flow measurement.

2.5 INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

A. Where specified or scheduled, provide pumps with an integral pump motor speed controller.

1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
2. Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: BACnet™ MS/TP.
3. Commissioning and pump set up access to pump controls via the following:

    a. A web interface (data exchange).
    b. A user interface located on the face of speed controller to adjust modes and mode values.
    c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.

4. Provide electronics with "Auto" as factory default but slope of the proportional curve will automatically match the required system curve, constant pressure control (delta-p/c), variable differential pressure control (delta-p/v), constant curve duty (uncontrolled pump), and rpm regulation. RPM (speed) regulation can be accomplished by the following:

    a. Manual (via user interface or HTML).
    b. Remote via 0 to 10 V dc.
    c. Data protocol communications with the BMS.

5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.

7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
8. Pump capable of being monitored continuously via integrated Internet link.
9. Integrated pump controller system to have the following features:

    a. Controller software shall be capable of sensorless control in variable-volume systems without need for pump-mounted (internal/external) or remotely mounted differential pressure sensor.
    b. Integrated Pump Controller Sensorless Control: Operates under Quadratic Pressure Control (QPC) to ensure that head reduction with reducing flow conforms to quadratic control curve.
    c. Controller:

        1) Minimum head of 40 percent of design duty head.
        2) User-adjustable control mode settings and minimum/maximum head set points using built-in programming interface.

    d. Controller Integrated Control Software:

        1) Capable of controlling pump performance for non-overloading power at every point of operation.
        2) Capable of maintaining flow rate data.

2.6 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide pumps so they are specified or scheduled with ECM.

1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.2 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

D. Comply with pump and coupling manufacturers' written instructions.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Hydronic pumps will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 233113 - METAL DUCTS

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. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.5 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 including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.
    g. Fire alarm devices.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. 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."

C. 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."

D. 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."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. 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."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. 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."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. 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."

2.3 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: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. 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.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. 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.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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

    a. CertainTeed Corporation; Insulation Group.
    b. Johns Manville.
    c. Knauf Insulation.
    d. Owens Corning.
    e. Maximum Thermal Conductivity:

        1) Type I, Flexible: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
            a) Certainteed ToughGard Type 300
        2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

    a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. 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.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

2.5 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. 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.

C. 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).

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

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. 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.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect’s intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 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 round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. 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.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.3 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.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Supply-Air Ducts in Pressure Seal Class A.
3. Exhaust Ducts: Seal Class B.
4. Return-Air Ducts: Seal Class B.

3.5 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.

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 a maximum intervals of 16 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.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

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

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Supply, Return and Exhaust Ducts: Test representative duct sections, selected by Engineer or Commissioning Agent from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.

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. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

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 Engineer or Commissioning Agent 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.

3.9 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. All new Supply Ducts: :

a. Pressure Class: Positive 2-inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. All new Return Ducts:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:

1. All new Exhaust Ducts:

    a. Pressure Class: Negative 2-inch wg.
    b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Underground supply and return ducts
1. 18 gauge type 316, welded stainless-steel sheet.

F. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. All Outdoor Ducts:

    a. Pressure Class: Positive or negative 2-inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

G. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts:

    a. Exposed to Airstream: Match duct material.
    b. Not Exposed to Airstream: Match duct material.

H. Liner:

1. Supply and Return Air Ducts in mechanical rooms, under raised basement floor, in attics and in shafts: Fibrous glass, Type I, 1-1/2 inches thick.
2. Supply and Return Air Ducts in joist bays, stud cavities and above dropped plaster ceilings: Fibrous glass, Type I, 1/2 inch thick.

I. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) 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."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) 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. 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."

3. 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.
1) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

J. 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 and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,".

a. 45-degree lateral.

END OF SECTION 233113

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SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Duct access panel assemblies.
10. Flexible connectors.
11. Duct accessory hardware.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Sustainable Design Submittals:

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

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 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Performance:

1. Maximum Air Velocity: 2000 fpm.
2. Maximum System Pressure: 2 inches wg.
3. AMCA Certification: Test and rate in accordance with AMCA 511.
4. Leakage:

    a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

C. Construction:

1. Frame:

    a. Hat shaped.
    b. 16-gauge-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

2. Blades:

    a. Multiple single-piece blades.

b. Center Off-center pivoted, maximum 6-inch width, 16-gauge-thick, galvanized sheet steel with sealed edges.

3. Blade Action: Parallel.

D. Blade Seals: Neoprene, mechanically locked.

E. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

H. Bearings: Steel ball or synthetic pivot bushings.

I. Damper Actuator - Electric:

1. Electric - 120 V ac 24 V ac.
2. UL 873 plenum rated.
3. Two position.

a. Sufficient motor torque to drive damper fully closed with adequate force to achieve required damper seal.
b. Minimum 90-degree drive rotation.

4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:

a. Temperature: Minus 40 to plus 130 deg F.
b. Humidity: 5 to 95 percent relative humidity noncondensing.

6. Environmental Enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

J. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hz 24 V, 60 Hz.

K. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. Screen Mounting:

a. Front mounted in sleeve.

1) Sleeve Thickness: 20 gauge minimum.
2) Sleeve Length: 6 inches minimum.

5. Screen Material: Galvanized steel.
6. Screen Type: Bird.
7. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

   a. McGill AirFlow LLC.
   b. Nailor Industries Inc.
   c. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

2. Performance:

   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Construction:

   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.

4. Frames:

   a. Hat-shaped, 16-gauge-thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized steel; 16 gauge thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

   a. Molded synthetic.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. 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.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

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

1. Greenheck Fan Corporation.
2. McGill AirFlow LLC.
3. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:

    a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.

2. Suitable for horizontal or vertical airflow applications.
3. Frames:

    a. Hat, U, or angle shaped.
    b. 16-gauge-thick, galvanized sheet steel.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple blade with maximum blade width of 8 inches.
    b. Opposed-blade design.
    c. Galvanized steel.
    d. 16-gauge-thick single skin.

5. Blade Edging Seals:

    a. Replaceable Closed-cell neoprene.
    b. Inflatable seal blade edging, or replaceable rubber seals.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:

    a. Molded synthetic.
    b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

E. Damper Actuator - Electric:

1. Electric - 24 V ac.
2. UL 873, plenum rated.
3. Fully modulating.

    a. Sufficient motor torqueto drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Minimum 90-degree drive rotation.

4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:

    a. Temperature: Minus 40 to plus 130 deg F.
    b. Humidity: 5 to 95 percent relative humidity noncondensing.

6. Environmental enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

F. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Fully modulating with positioner and fail-safe spring return.

    a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.

3. Actuator to be factory mounted.

G. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 24 V, 60 Hz.

2.5 FIRE DAMPERS

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

1. Greenheck Fan Corporation.
2. Pottorff.
3. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

B. Type: Static and dynamic; rated and labeled in accordance with UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed galvanized sheet steel,. Material gauge is to be in accordance with UL listing.

I. Horizontal Dampers: Include blade lock and stainless steel closure spring.

J. Heat-Responsive Device:

1. Replaceable, 212 deg F rated, fusible links.
2. Electric, link and switch package, factory installed, 165 deg F and 212 deg F rated.

2.6 SMOKE DAMPERS

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

1. Greenheck Fan Corporation.
2. Pottorff.
3. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
4. .

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
2. Leakage:

    a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Suitable for horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:

    a. Hat shaped.
    b. Galvanized sheet steel, with welded corners and mounting flange.
    c. Gauge in accordance with UL listing.

4. Blades:

    a. Roll-formed, horizontal, airfoil,.
    b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

    a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
8. Bearings:

    a. Molded synthetic.

E. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking; gauge in accordance with UL listing.

F. Damper Actuator - Electric:

1. Electric - 120 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.

    a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.
    c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

    a. Temperature: Minus 40 to plus 130 deg F.
    b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

G. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hz] [**24 V, 60 Hz**] <**Insert values**>.

H. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Test and reset switches, remote mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.7 FLANGE CONNECTORS

A. Description: [**Add-on**] [**or**] [**roll-formed**], factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.8 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply 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."

D. Vane Construction:

1. Single wall.
2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. 24-gauge-thick galvanized steel door panel.
d. Vision panel.
e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
f. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

a. 24-gauge-thick galvanized steel or 0.032-inch-thick aluminum frame.

3. Number of Hinges and Locks:

   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Continuous and two sash locks.

2.10 DUCT ACCESS PANEL ASSEMBLIES

A. Access panels used in cooking applications:

   1. Labeled compliant to NFPA 96 for grease duct access doors.
   2. Labeled in accordance with UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 16-gauge carbon steel.

C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10 inches wg positive or negative.

2.11 FLEXIBLE CONNECTORS

A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. 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.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

H. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

2.12 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.

2.13 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 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. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. 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.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire and smoke dampers in accordance with UL listing.

I. 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 and downstream 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. At each change in direction and at maximum 50-ft. spacing.
8. Upstream and downstream from turning vanes.
9. For grease ducts, install at locations and spacing as required by NFPA 96.
10. Control devices requiring inspection.

11. Elsewhere as indicated.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

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 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 size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

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. Ceiling-mounted ventilators.
2. Sidewall propeller fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.

C. Delegated Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

C. Product Certificates: Submit certificates that specified equipment will withstand required wind forces, from manufacturer.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Seismic Performance: HVAC power ventilators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Component Importance Factor: 1.5.

G. Wind Performance: Air-handling units shall withstand the effects of wind determined in accordance with to ASCE/SEI 7.

H. Capacities and Characteristics: See Drawings

2.2 CEILING-MOUNTED VENTILATORS

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. PennBarry; division of Air System Components.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.

D. Back-draft damper: Integral.

E. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 SIDEWALL PROPELLER FANS

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

1. Carnes Company.
2. Loren Cook Company.
3. PennBarry; division of Air System Components.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

C. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.

D. Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

F. Fan Drive, Belt:

1. Belt drive.
2. Resiliently mounted to housing.
3. Statically and dynamically balanced.

4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
5. Extend grease fitting to accessible location outside of unit.
6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L(10) of 100,000 hours.

9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.
6. Weathershield Hood: Galvanized steel to match fan and accessory size.
7. Weathershield Front Guard: Galvanized steel with expanded metal screen.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
2. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK 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 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 STARTUP SERVICE:

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, 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.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.
3. Fans and components will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

3.9 DEMONSTRATION

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

END OF SECTION 233423

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SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

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. Rectangular and square ceiling diffusers.
2. Linear bar floor diffusers.
3. Adjustable bar registers and grilles.
4. Fixed face registers and grilles.
5. Linear bar grilles.

B. Related Sections:
1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 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.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Method of attaching hangers to building structure.
2. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:

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

    a. A-J Manufacturing Co., Inc.
    b. Anemostat Products; a Mestek company.
    c. Carnes.
    d. Hart & Cooley Inc.
    e. Krueger.
    f. METALAIRE, Inc.
    g. Nailor Industries Inc.
    h. Price Industries.
    i. Titus.
    j. Tuttle & Bailey.
2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Size: As specified on drawings.
5. Face Style: As specified on drawings.
6. Mounting: Surface.
7. Pattern: As specified on drawings.
8. Dampers: Combination damper and grid.
9. Accessories:

    a. Equalizing grid.
    b. Plaster ring.
    c. Safety chain.
    d. Wire guard.
    e. Sectorizing baffles.
    f. Operating rod extension.

2.2 UNDERFLOOR AIR DISTRIBUTION DIFFUSERS

A. Linear Bar Floor Diffuser:

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

    a. Air Research Diffuser Products, Inc.
    b. Anemostat Products; a Mestek company.
    c. Carnes.
    d. Hart & Cooley Inc.
    e. Krueger.
    f. METALAIRE, Inc.
    g. Nailor Industries Inc.

h. Price Industries.
i. Titus.

2. Material: Steel.
3. Finish: As specified on drawings.
4. Deflection: As specified on drawings.
5. Components:

a. Aluminum diffuser core.
b. Diffuser frame.
c. Plenum, 0.034-inch steel.

2.3 REGISTERS AND GRILLES

A. Adjustable Bar Register and Grille:

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

a. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.
e. Hart & Cooley Inc.
f. Krueger.
g. METALAIRE, Inc.
h. Nailor Industries Inc.
i. Price Industries.
j. Titus.
k. Tuttle & Bailey.

2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: As specified on drawings.
5. Rear-Blade Arrangement: As specified on drawings.
6. Frame As specified on drawings.
7. Mounting: Countersunk screw.
8. Damper Type: Adjustable opposed blade.

B. Fixed Face Register and Grille:

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

a. A-J Manufacturing Co., Inc.
b. Anemostat Products; a Mestek company.
c. Carnes.
d. Dayus Register & Grille Inc.
e. Hart & Cooley Inc.
f. Krueger.

g. Nailor Industries Inc.
h. Price Industries.
i. Titus.
j. Tuttle & Bailey.

2. Material: Steel or Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Arrangement: As specified on drawings.
5. Frame: As specified on drawings.
6. Mounting: As specified on drawings
7. Damper Type: Adjustable opposed blade.

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 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the

Architect's direction. Additional payment will not be made for the cost of relocating elements that were not installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 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.

3.3 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.

3.4 ADJUSTING

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

END OF SECTION 233713

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SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, concealed, high static, ceiling-mounted units for ducting.
2. Indoor, vertical/horizontal ducted multi-position air handler.
3. Indoor, exposed, wall-mounted units.
4. Outdoor, air-source heat recovery units.
5. Heat recovery control units.
6. System controls.
7. System refrigerant and oil.
8. System condensate drain piping.
9. System hydronic piping.
10. System refrigerant piping.
11. Metal hangers and supports.
12. Metal framing systems.
13. Fastener systems.
14. Equipment stands.
15. Miscellaneous support materials.
16. Piping and tubing insulation.
17. System control cable and raceways.

1.2 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

E. 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.

F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.

I. VRF: Variable refrigerant flow.

1.3 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, using input from installers of the items involved.

B. Qualification Data:

1. For Installer.
2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

C. Product Certificates: For each type of product.

D. Product test reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within 75 miles of Project.
3. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

    a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
    b. Demonstrated past experience on five projects of similar complexity, scope, and value.

C. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period:

    a. For Compressor: Seven year(s) from date of Substantial Completion.
    b. For Parts, Including Controls: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
1. Mitsubishi Electric & Electronic, USA
2. Trane Company
3. Panasonic Corporation of North America
4. Daikin AC

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe or three-pipe system design.
2. System(s) operation, air-conditioning heat pump or heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 135: For control network protocol with remote communication.
3. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

B. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

C. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

D. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:
1. Range acceptable to manufacturer.

E. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

F. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

G. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

a. Design equipment and supports to withstand wind loads of governing code.
b. Design equipment and supports to withstand snow and ice loads of governing code.
c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: 92 degrees F.
3. Minimum System Operating Outdoor Temperature: 2 degrees F.

H. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: See Drawings.
2. Outdoor: See Drawings.

I. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

J. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, HIGH STATIC CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. The unit shall have self-diagnostic function, 3-minute time delay mechanism and auto restart function.

C. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

D. DX Coil Assembly:

1. Coil Casing: Aluminum or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance with inner grooves for high efficiency heat exchange.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.

5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

E. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation of 27 inches above condensate pan.
3. Field Piping Connection: Non-ferrous material.

F. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Auto-fan function
6. Vibration Control: Integral isolation to dampen vibration transmission.

G. Filter Assembly:

1. Separate factory fabricated filter housing with separate tracks for pre-filter and final filter.
2. See drawing schedule for filter housing and filters.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit inlet air temperature.
    b. Coil entering refrigerant temperature.
    c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:
    a. Analog Inputs: Four for use in customizable control strategies.
    b. Digital Inputs: Four for use in customizable control strategies.
    c. Digital Outputs: Three for use in customizable control strategies.

5. Features and Functions:

    a. Self-diagnostics.
    b. Time delay.
    c. Auto-restart.
    d. External static pressure control.
    e. Auto operation mode.
    f. Manual operation mode.
    g. Filter service notification.
    h. Power consumption display.
    i. Drain assembly high water level safety shutdown and notification.
    j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, VERTICAL/HORIZONTAL DUCTED MULTI-POSITION AIR HANDLER

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.

2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Materials: Non-ferrous components or ferrous components with corrosion resistant finish.
d. Statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Separate factory fabricated filter housing with separate tracks for pre-filter and final filter.

2. See drawing schedule for filter housing and filters.

G. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:
a. Analog Inputs: Four for use in customizable control strategies.

b. Digital Inputs: Four for use in customizable control strategies.
c. Digital Outputs: Three for use in customizable control strategies.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay, auto-restart.
c. External static pressure control.
d. Auto operation mode.
e. Manual operation mode.
f. Filter service notification.
g. Power consumption display.
h. Drain assembly high water level safety shutdown and notification.
i. Run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways.

2.6 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable white finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.

2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.
10. Factory installed LEV/EEV.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

    a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top of unit cabinet.
1. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

H. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature.
4. Field-Customizable I/O Capability:

    a. Analog Inputs: Four for use in customizable control strategies.
    b. Digital Inputs: Four for use in customizable control strategies.
    c. Digital Outputs: Three for use in customizable control strategies.

5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, manual operation mode, filter service notification, drain assembly high water level safety shutdown and notification.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

2.7 OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

    a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.

3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 20 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Refrigerant and Refrigerant Piping:
1. R410A refrigerant shall be required for systems.
2. Polyolester (POE) oil
3. Refrigerant piping shall be phosphorus deoxidized copper (copper and copper alloy seamless pipes) of sufficient radial thickness as defined by the VRF equipment manufacturer and installed in accordance with manufacturer recommendations.
4. All refrigerant piping must be insulated with ½" closed cell, CFC-free foam insulation with flame-Spread Index of less than 25 and a smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102. R value of insulation must be at least 3.
5. Refrigerant line sizing shall be in accordance with manufacturer specifications. Future changes to indoor unit styles or sizes must be possible without resizing/replacing refrigerant piping to any other branch devices or indoor units

E. Condenser Coil Assembly:

1. Plate Fin Coils:

    a. Casing: Aluminum or stainless steel.

    b. The coil shall be protected with an integral metal guard.
    c. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
    d. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
b. Single- or multiple-pass arrangement.
c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Coating: Corrosion resistant.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

F. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.
7. Fans shall be capable of normal operation with a maximum of 0.24 in. WG external static pressure via dipswitch

G. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

H. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Refrigerant suction temperature.
b. Refrigerant discharge temperature.
c. Outdoor air temperature.
d. Refrigerant high pressure.
e. Refrigerant low pressure.
f. Oil level.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode, night setback control, equalize run time between multiple same components.
5. Communication: Network communication with indoor units and other outdoor unit(s).

6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

J. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B117.

2.8 HEAT RECOVERY CONTROL UNITS (HRCUs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. Each unit shall be completely factory assembled, piped and wired, and shall be run tested at the factory.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.

2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
3. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance.
4. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
5. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
6. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

    a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Features and Functions: Self-diagnostics, fuse protection.
4. Communication: Network communication with indoor units and outdoor unit(s).
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.9 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration shall include control, monitoring, scheduling change of value notifications.

4. Operator Interface:

    a. Operators shall interface with system and unit controls through the following:

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controller(s).
        3) Web interface through web browser software.
        4) Integration with Building Automation System.

    b. Users shall be capable of interface with controllers for control of indoor units to extent privileges are enabled. Control features available to users shall include the following:

        1) On/off control.
        2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Imperial and Metric Temperature Units: Fahrenheit and Celsius.
10. Displays service notifications and error codes.
11. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
12. Monitors and displays cumulative operating time of indoor units.
13. Able to disable and enable operation of individual controllers for indoor units.
14. Information displayed on individual controllers shall also be available for display.
15. Information displayed for outdoor units, including refrigerant high and low pressures.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

    a. Include multiple interconnected controllers as required.

2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.
    b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Temperature Units: Fahrenheit and Celsius.

4. On/Off: Turns indoor unit on or off.
5. Hold: Hold operation settings until hold is released.
6. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
7. Temperature Display: 1-degree increments.
8. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 50F to 85F.
9. Relative Humidity Display: 1 percent increments.
10. Relative Humidity Set-Point: Adjustable in 1 percent increments between 40% to 60%.
11. Fan Speed Setting: Select between available options furnished with the unit.
12. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
13. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
14. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
15. Occupancy detection.
16. Service Notification Display: "Filter".
17. Service Run Tests: Limit use by service personnel to troubleshoot operation.
18. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
19. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
20. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
21. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.10 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a.

B. Oil:

1. Polyolester (POE).

2.11 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B88, Type L or Type DWV according to ASTM B306.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.

4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

2.12 SYSTEM HYDRONIC PIPING

A. Comply with requirements in Section 232113 "Hydronic Piping" for system piping requirements.

2.13 SYSTEM REFRIGERANT PIPING

A. Refrigerant Piping:

1. Copper Tube: ASTM B280, Type ACR.
2. Wrought-Copper Fittings: ASME B16.22.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

B. Refrigerant Tubing Kits:

1. Furnished by VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
3. Standard one-piece length for connecting to indoor units.
4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
5. Factory Charge: Dehydrated air or nitrogen.

C. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

D. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.14 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

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

2.15 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

    a. B-line, an Eaton business.
    b. Haydon Corporation.
    c. MIRO Industries.
    d. Thomas & Betts Corporation; A Member of the ABB Group.
    e. Unistrut; Part of Atkore International.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with in-turned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
7. Metallic Coating for Use Indoors: Electroplated zinc.
8. Plastic Coating for Use Outdoors: PVC or epoxy.

2.16 FASTENER SYSTEMS

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

1. Indoor Applications: Zinc-coated or stainless steel.
2. Outdoor Applications: Stainless steel.

2.17 OUTDOOR EQUIPMENT STANDS

A. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.

B. Foot Material: Rubber or polypropylene.

C. Rails Material: Hot-dip galvanized carbon steel.

D. Wind/Sliding Load Resistance: Up to 105 mph minimum.

2.18 MISCELLANEOUS SUPPORT MATERIALS

A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.19 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.

B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
b. Indoors: 1/2 inch thick.
c. Outdoors: 1/2 inch Insert dimension thick.

2. Field-Applied Jacket:

a. Concealed: None required.
b. Indoors, Exposed to View: None required.
c. Outdoors, Exposed to View: None required.

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
b. Indoors: 1 inch thick.
c. Outdoors: 1 inch thick.

2. Field-Applied Jacket:

a. Concealed: None required.
b. Indoors, Exposed to View: None required.
c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch thick Insert jacket.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.20 SYSTEM CONTROL CABLE AND RACEWAYS

A. Low-Voltage Control Cabling:

1. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

B. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.
2. Plenum-Rated Cable: NFPA 70, Type CMP.

C. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors or as recommended by manufacturer.

D. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.21 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.
b. ASTM D2794 for minimum impact resistance of 100 in-lb.
c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.22 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 NOTE REGARDING INSTALLATION OF FIRE ALARM, FIRE PROTECTION, HVAC, PLUMBING AND ELECTRICAL DEVICES:

A. The Architect's intention is to align and/or center wall-mounted devices, typically, and ceiling-mounted devices as well, whether those devices are provided by the electrician, plumber, sprinkler installer, mechanical sub-contractor, or others. For walls, these devices and their alignments may be indicated on interior elevations or building sections, but, regardless, it is expected that adjustments may need to be made in the field, or that additional items may be required. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include sconces, switches, thermostats and electrical outlets, where located close to one another, and may also include wall diffusers, side-mounted sprinkler heads, return grilles, access panels, pull stations, horns and strobes, etc.

B. In ceilings, the Architect's intention is to center ceiling-mounted elements within a space or a room, and/or to align them with one another. These devices and their alignments may be indicated on the reflected ceiling plans, but it is expected that adjustments may need to be made in the field, or that additional items may be required to be mounted. The installation of all such items shall be as reviewed and approved by the Architect. The devices to be aligned and/or centered may include lights, HVAC equipment, access panels, diffusers and returns, sprinkler heads, paddle fans, ceiling lights, exhaust fans, smoke detectors, etc. If the ceiling is of a modular type (panels), it is expected that device locations will also be coordinated and aligned and/or centered within the panels.

C. The General Contractor shall coordinate the various trades involved in providing and installing such wall- and ceiling-mounted devices before any installation begins, in accordance with the requirement for a preliminary coordination meeting called for elsewhere in these specifications. The General Contractor shall review approaches to locating devices, and specific device locations, with the Architect before roughing. Roughed items that do not comply with the intentions of this section, or with the architectural drawings, shall be relocated per the Architect's direction. Additional payment will not be made for the cost of relocating elements that were not

installed in accordance with these intentions or with the Architect's approval, or for the cost of patching of finishes that might be necessary by such relocation.

3.2 EQUIPMENT INSTALLATION

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

1. Loose components shall be installed by either the manufacturer's service representative or the system Installer under supervision of manufacturer's service representative.

C. Indoor Unit Installations:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
3. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
4. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
5. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
6. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
7. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.
8. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
9. Floor-mounted units located in mechanical rooms.
10. Install floor-mounted units on support structure indicated on Drawings.
11. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
12. Attachment: Install hardware for proper attachment to supported equipment.
13. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Outdoor Unit Installations:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Install outdoor units on support structures indicated on Drawings.
3. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

    a. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.

b. Grouting: Place grout under equipment supports and make bearing surface smooth.

3.3 GENERAL REQUIREMENTS FOR PIPING AND TUBING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at slopes recommended by manufacturer.

G. Install piping and tubing free of sags.

H. Install fittings for changes in direction and branch connections.

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors.

3.4 CONDENSATE DRAIN PIPE AND TUBING INSTALLATION

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.

c. Governing codes.
d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.5 REFRIGERANT PIPING AND TUBING INSTALLATION

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 3/8 inch.
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

I. When brazing, remove or protect components that could be damaged by heat.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

K. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

    a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
    b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.6 PIPE AND TUBING INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

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

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

E. 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 SOFTWARE

A. Cybersecurity:

1. Software:

a. Coordinate security requirements with Owner.
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

a. Coordinate location and access requirements with Owner.
b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
c. Disable dual network connections.

3.8 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

C. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

D. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

E. Products will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

    a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect and Owner to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.11 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

3.12 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.13 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

END OF SECTION 238129

SECTION 238146.13 - WATER-TO-AIR HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concealed horizontal or vertical units, 6 tons and smaller.
2. Exposed, floor-mounted console units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. ASHRAE Compliance:

1. ASHRAE 15.
2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Comply with NFPA 70.

D. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

E. Comply with safety requirements in UL 1995 for duct-system connections.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: [Four] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS AND SMALLER

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Flanged duct connections.
4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch thick, complying with UL 181, ASTM C1071, and ASTM G21.
5. Units field convertible for various discharge configurations.
6. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting through unit cabinet and complying with ASHRAE 62.1.

a. Condensate Overflow Protection Switch: Solid state electronic; mechanical float switch not permitted.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Direct driven, centrifugal, with multispeed motor resiliently mounted in fan inlet and with inlet rings to allow wheel removal from one side without removing housing.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor: Multispeed, permanently lubricated, [permanent split capacitor] [ECM] motor.

D. Water Circuit:

1. Refrigerant-to-Water Heat Exchangers:

    a. Coaxial heat exchangers with [copper] [cupronickel] water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
    b. Stainless-steel, brazed-plate heat exchanger is leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

E. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig.

F. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic [rotary] [reciprocating] [scroll], [single-stage] [two-stage] compressor installed on vibration isolators and housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss of charge switch.
    d. Internal thermal-overload protection.
    e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below [35 deg F] <Insert temperature>.
    f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
    g. Water-coil, low-temperature switch.
    h. Air-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch-thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device: Thermal-expansion valve.
9. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from [25 to 125 deg F] <Insert temperature range>.

10. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.

G. Electric Heating Coil: Helix-wound, nickel-chromium, wire-heating elements in ceramic insulators mounted on steel supports. Energize on call for heating when entering-water-loop temperature is less than [25 deg F] [40 deg F] [60 deg F] <Insert temperature>.

H. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

I. Filters: Disposable, glass-fiber, flat type, [1 inch] <Insert dimension> thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.

J. Filters: Disposable, pleated type, [1 inch] <Insert dimension> thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

K. Controls:

1. Basic Unit Control Modes and Devices:

a. Dehumidification mode.
b. Unit shutdown on high or low refrigerant pressures.
c. Unit shutdown on low water temperature.
d. Low- and high-voltage protection.
e. Overcurrent protection for compressor and fan motor.
f. Random time delay, three to ten seconds, start on power-up.
g. Time delay override for servicing.
h. Control voltage transformer.
i. Water-coil freeze protection (selectable for water or antifreeze).
j. Air-coil freeze protection (check filter switch).
k. Condensate overflow shutdown switch.
l. Option to reset unit at thermostat or disconnect.
m. Fault type shall be retained in memory if reset at thermostat.
n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
o. Ability to defeat time delays for servicing.
p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
r. Remote fault-type indication at thermostat.
s. Selectable 24-V dc or pilot duty dry contact alarm output.
t. 24-V dc output to cycle a motorized water valve with compressor contactor.
u. Electric heat output to control two stages of electric heat (emergency heat).
v. Service test mode for troubleshooting and service.
w. Unit-performance sentinel warns when the heat pump is running inefficiently.

2. Thermostat:

a. Wall-Mounted Thermostat:

1) Heat-cool-off switch.
2) Fan on-auto switch.
3) [Manual] [Automatic] changeover.
4) [Concealed] [Exposed] temperature set point.
5) [Concealed] [Exposed] temperature indication.
6) Deg [F] [C] indication.

b. Wall-Mounted Humidistat: [Concealed] [Exposed].

1) Temperature set point.
2) Temperature indication.

c. Wall-mounted temperature sensor.
d. Unoccupied period override push button.
e. LED to indicate fault condition at heat pump.
f. Data entry and access port.

1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:

a. Scheduled operation for occupied and unoccupied periods on [seven] [365]-day clock with minimum of four programmable periods per day.
b. [Two] <Insert number>-hour unoccupied override period.
c. Remote-control panel to contain programmable timer and LED for fault condition.
d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
g. Backup for volatile memory.
h. Differential pressure switch to indicate fan status. Fan failure alarm.
i. Differential pressure switch to indicate filter status. Dirty filter alarm.

L. Electrical Connection: Single electrical connection[with fused disconnect].

M. Capacities and Characteristics:

1. Fan:

a. Airflow: <Insert cfm>.
b. External Static Pressure: <Insert inches wg>.
c. Fan Speed: <Insert rpm>.
d. Motor Speed: <Insert rpm>.
e. Motor Horsepower: <Insert value>.

2. Water Supply:

a. Water Flow: <Insert gpm>.
b. Pressure Loss: <Insert feet wg>.
c. Entering-Water Temperature (Cooling): <Insert deg F>.
d. Entering-Water Temperature (Heating): <Insert deg F>.
e. Antifreeze Protection Chemical: <Insert chemical name>.
f. Antifreeze Concentration: <Insert percentage>.

3. Cooling:

a. Total Capacity: <Insert Btu/h>.
b. Sensible Capacity: <Insert Btu/h>.
c. Minimum Energy-Efficiency Ratio (EER): <Insert value>.
d. Entering-Air Temperature Dry Bulb: <Insert deg F>.
e. Entering-Air Temperature Wet Bulb: <Insert deg F>.

4. Heating:

a. Capacity: <Insert Btu/h>.
b. Entering-Air Temperature: <Insert deg F>.
c. Air Temperature Rise: <Insert deg F>.
d. Minimum Coefficient of Performance (COP): <Insert value>.

5. Electric Heating Coil (Optional Feature):

a. Capacity: <Insert Btu/h>.
b. Number of Steps: <Insert number>.

6. Filters:

a. Face Area: <Insert sq. ft. >.
b. Maximum Face Velocity: <Insert fpm>.

7. Electrical Characteristics for Single Connection:

a. Volts: [120] [208] [230] <Insert value>.
b. Phase: [Single] [Three].
c. Hertz: 60.
d. Full-Load Amperes (F.L.A.): <Insert value>.
e. Maximum Circuit Amperage (MCA): <Insert value>.
f. Maximum Overcurrent Protection (MOCP): <Insert amperes>.

2.2 EXPOSED, CONSOLE WATER-SOURCE HEAT PUMPS

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

B. Cabinet and Chassis: Manufacturer's [standard] [low] [standard- and low]-height, [flat] [sloped]-top, [extended]galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch thick, complying with UL 181, ASTM C1071, and ASTM G21.
4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch thick, complying with ASTM C1071 and NAIMA AH124, "Fibrous Glass Duct Liner Standard."
5. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting to unit exterior and complying with ASHRAE 62.1.

    a. Condensate Overflow Protection: Solid state electronic; mechanical float switch not permitted.

6. Discharge Grille: Steel, aluminum, or plastic grille for adjustable discharge air pattern.
7. Color: Selected by Architect from manufacturer's [standard] [custom] color selection.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Direct driven, centrifugal, with multispeed motor mounted on a removable fan-motor board.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor: Multispeed, permanently lubricated, [permanent split capacitor] [ECM].

D. Water Circuit:

1. Refrigerant-to-Water Heat Exchanger: Coaxial heat exchanger with [copper] [cupronickel] water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig for refrigerant side and 400 psig for water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.

E. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig.

F. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic rotary compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.

c. Low-pressure cutout or loss of charge switch.
d. Internal thermal-overload protection.
e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below [35 deg F] <Insert temperature>.
f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
g. Water-coil, low-temperature switch.
h. Air-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch-thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes per ASTM E84.
8. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from [25 to 125 deg F] <Insert temperature range>.
9. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.

G. Electric Heating Coil: Energized on call for heating when entering-water-loop temperature is less than [60 deg F] <Insert temperature>.

H. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when [remote] [unit-mounted] humidistat calls for dehumidification.

I. Outdoor-Air Damper: Two-position, [manual] [motorized] outdoor-air damper for fixed minimum intake up to 25 percent of fan capacity.

J. Filters: Disposable, glass-fiber, flat type, [1 inch] <Insert dimension> thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.

K. Filters: Disposable, pleated type, [1 inch] <Insert dimension> thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

L. Controls:

1. Basic Unit Control Modes and Devices:

a. Dehumidification mode.
b. Unit shutdown on high or low refrigerant pressures.
c. Unit shutdown on low water temperature.
d. Low- and high-voltage protection.
e. Overcurrent protection for compressor and fan motor.
f. Random time delay, three to ten seconds, start on power-up.
g. Time delay override for servicing.
h. Control voltage transformer.
i. Water-coil freeze protection (selectable for water or antifreeze).
j. Air-coil freeze protection (check filter switch).
k. Condensate overflow shutdown switch.
l. Option to reset unit at thermostat or disconnect.
m. Fault type shall be retained in memory if reset at thermostat.

n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
o. Ability to defeat time delays for servicing.
p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
r. Remote fault-type indication at thermostat.
s. Selectable 24-V dc or pilot duty dry contact alarm output.
t. 24V dc output to cycle a motorized water valve with compressor contactor.
u. Electric heat output to control two stages of electric heat (emergency heat).
v. Service test mode for troubleshooting and service.
w. Unit-performance sentinel warns when the heat pump is running inefficiently.

2. Thermostat:

a. [Wall] [Unit]-Mounted Thermostat:

1) Heat-cool-off switch.
2) Fan on-auto switch.
3) [Manual] [Automatic] changeover.
4) [Concealed] [Exposed] temperature set point.
5) [Concealed] [Exposed] temperature indication.
6) Deg [F] [C] indication.

b. [Wall] [Unit]-Mounted Humidistat: [Concealed] [Exposed].

1) Temperature set point.
2) Temperature indication.

c. [Wall] [Unit]-mounted temperature sensor.
d. Unoccupied period override push button.
e. LED to indicate fault condition at heat pump.
f. Data entry and access port.

1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:

a. Scheduled operation for occupied and unoccupied periods on [seven] [365]-day clock with minimum of four programmable periods per day.
b. [Two] <Insert number>-hour unoccupied override period.
c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
e. Backup for volatile memory.

f. Differential pressure switch to indicate fan status. Fan failure alarm.
g. Differential pressure switch to indicate filter status. Dirty filter alarm.

M. Electrical Connection: Single electrical connection[with fused disconnect].

N. Capacities and Characteristics:

1. Fan:

a. Airflow: <Insert cfm>.
b. External Static Pressure: <Insert inches wg>.
c. Fan Speed: <Insert rpm>.
d. Motor Speed: <Insert rpm>.
e. Motor Horsepower: <Insert value>.

2. Water Supply:

a. Water Flow: <Insert gpm>.
b. Pressure Loss: <Insert feet wg>.
c. Entering-Water Temperature (Cooling): <Insert deg F>.
d. Entering-Water Temperature (Heating): <Insert deg F>.
e. Antifreeze Protection Chemical: <Insert chemical name>.
f. Antifreeze Concentration: <Insert percentage>.

3. Cooling:

a. Total Capacity: <Insert Btu/h>.
b. Sensible Capacity: <Insert Btu/h>.
c. Minimum Energy-Efficiency Ratio (EER): <Insert value>.
d. Entering-Air Temperature Dry Bulb: <Insert deg F>.
e. Entering-Air Temperature Wet Bulb: <Insert deg F>.

4. Heating:

a. Capacity: <Insert Btu/h>.
b. Entering-Air Temperature: <Insert deg F>.
c. Air Temperature Rise: <Insert deg F>.
d. Minimum Coefficient of Performance (COP): <Insert value>.

5. Electric Heating Coil (Optional Feature):

a. Capacity: <Insert Btu/h>.
b. Number of Steps: <Insert number>.

6. Filters:

a. Face Area: <Insert sq. ft. >.
b. Maximum Face Velocity: <Insert fpm>.

7. Electrical Characteristics for Single Connection:

a. Volts/Phase/Hertz: <Insert values>.

b. Full-Load Amperes (F.L.A.): <Insert value>.
c. Maximum Circuit Amperage (MCA): <Insert value>.
d. Maximum Overcurrent Protection (MOCP): <Insert amperes>.

2.3 HOSE KITS

A. General: Hose kits shall be designed for minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

B. Hose: Length [24 inches] [36 inches] braided stainless steel, complete with adapters, <Insert dimension>. Minimum diameter, equal to water-source, heat-pump connection size.

C. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel, standard-port ball and stem with normal pipe thread (NPT) connections, and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig.
2. Manual, calibrated-orifice balancing valve.
3. Manual, venturi-type balancing valve.

F. Motorized Water Valve: Slow-acting, 24-V dc, with NPT connections.

2.4 HOSE KIT ASSEMBLIES

A. Supply and return hoses having ball valve with pressure temperature port.

B. Supply hose having ball valve with pressure temperature port; return hose having automatic flow regulator valve with pressure temperature ports, and ball valve.

C. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port; return hose having automatic flow regulator with PT ports, and ball valve.

D. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port.

E. Return hose having ball valve with pressure temperature port.

2.5 PUMP MODULE

A. Minimum [1/6] <Insert value>-hp, 230-V, single-phase pump rated to move at least [16 gpm] <Insert value> at [20-feet wg] <Insert value> head pressure.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.

C. Three-way brass shut-off/flushing/purging valve.

D. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor Mounting: Install water-source heat pumps using [elastomeric pads] [elastomeric mounts] [restrained spring isolators] <Insert device>. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [1/4 inch] [1 inch] <Insert dimension>.

B. Suspended Units: Install water-source heat pumps with continuous-thread hanger rods and [elastomeric hangers] [spring hangers] [spring hangers with vertical-limit stop] of size required to support weight of water-source heat pump unit.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923.27 "Temperature Instruments," Section 230923.19 "Moisture Instruments," and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Connect supply and return hydronic piping to heat pump.

E. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

F. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Install piping adjacent to machine to allow service and maintenance.

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238146.13

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SECTION 238146 - WATER-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes unitary heat pumps with refrigerant-to-water heat exchangers, refrigeration circuits, and refrigerant compressor(s).

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water-source unitary heat pumps, accessories, and components, from manufacturer.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water-source unitary heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: Four years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. ASHRAE 15.

B. Comply with NFPA 70.

C. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

2.2 WATER-SOURCE UNITARY HEAT PUMPS, 6 TONS AND SMALLER

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

1. Carrier Global Corporation.
2. ClimateMaster, Inc.
3. Trane Inc.

B. Description: Packaged water-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, minimum, 3/4 inch thick, complying with UL 181, ASTM C1071, and ASTM G21.

D. Water Circuits:

1. Refrigerant-to-Water Heat Exchangers:

a. Source-side coaxial heat exchangers with cupronickel water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig on refrigerant side and 400 psig on water side.
b. Stainless-steel, brazed-plate heat exchanger is leak tested to 450 psig on refrigerant side and 400 psig on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
c. Hot-water generator, copper water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig on refrigerant side and 400 psig on water side, pump, circuit breaker, high water temperature and low water refrigerant cutoffs, and tank connection.

E. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor:

    a. Scroll.
    b. Two stage.
    c. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
    d. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.
    e. Factory-Installed Safeties:

        1) Antirecycle timer.
        2) High-pressure cutout.
        3) Low-pressure cutout or loss of charge switch.
        4) Internal thermal-overload protection.
        5) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F.
        6) Water-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch-thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device: Thermal-expansion valve.
9. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F.

F. Controls: Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

G. Electrical Connection: Single electrical connection with fused disconnect.

2.3 ACCESSORIES

A. Hose Kits: Tag hose kits to equipment designations.

1. Minimum Working Pressure: 400 psig.
2. Operating Temperatures: From 33 to 211 deg F.
3. Hose Length: 24 inches.
4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.
5. Hose Material: Braided stainless steel with adapters for pipe connections.

6. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel ball and stem, standard-port threaded connections, and galvanized-steel lever handle. Valves shall be factory installed on supply and return connections of both load-side and source-side heat exchangers. If balancing valve is combination shutoff type with memory stop, the isolation valve may be omitted on the return.
7. Strainer: Y-pattern with blowdown valve in supply connections of both load and source side of heat exchangers.
8. Balancing Valves: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

    a. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a pressure range of 2 to 80 psig.

9. Water-Regulating Valve Assemblies: A direct acting valve regulates discharge pressure during the cooling cycle, and a reverse acting valve regulates the suction pressure during the heating cycle. Valves shall close when heat-pump compressor is not running.
10. Motorized Water Valve: Stop water flow through the unit when compressor is off. Slow-acting, 24-V dc valve with threaded connections is installed between isolation valves and heat exchanger.

B. Hose Kit Assemblies:

1. Minimum Working Pressure: 400-psig.
2. Operating Temperatures: From 33 to 211 deg F.
3. Hose Length: 24 inches.
4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.
5. Hose Material: Braided stainless steel with adapters for pipe connections.
6. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having automatic flow regulator with pressure-temperature ports and ball valve.
7. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having ball valve with pressure-temperature port.

C. Loop Controller: Six stages; two stages for heating and four stages for cooling.

D. Pump Module:
1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.
3. Three-way brass shut-off/flushing/purging valve.
4. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install water-source, unitary heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration-isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Suspend water-source, unitary heat pumps from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves hose kits.

E. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

F. Install piping adjacent to machine to allow space for service and maintenance.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. After installing water to water heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238146

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SECTION 238239.19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. INDEECO.
2. Marley Engineered Products.
3. QMark; Marley Engineered Products.

2.2 DESCRIPTION

A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

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.

2.3 CABINET

A. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.

B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

A. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

2.7 CAPACITIES AND CHARACTERISTICS

A. Airflow: See Drawings.

B. Fan Speed: See Drawings.

C. Heating Coil: See Drawings.

D. Electrical Characteristics for Single-Point Connection:

1. Volts: See Drawings.
2. Phase: See Drawings.
3. Hertz: See Drawings.
4. Full-Load Amperes: See Drawings.
5. Minimum Circuit Ampacity: See Drawings.
6. Maximum Overcurrent Protection: See Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

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SECTION 238416 - MECHANICAL DEHUMIDIFICATION UNITS

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 packaged, factory-assembled and -tested, refrigerant-type, mechanical dehumidification units designed for indoor installation.

1.3 ACTION SUBMITTALS

A. Product Data: For each dehumidification unit indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each dehumidification unit indicated. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

C. Warranty: Sample of warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For dehumidification units to include in operation and 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. Filters: One set of each type of filter specified.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment" and Section 7, "Construction and Startup."
2. Applicable requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of dehumidification units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Manufacturer's standard, but not less than five years from 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. Comitale National Inc.
2. Dectron Internationale.
3. Dehumidifier Corporation of America.
4. Desert Aire.
5. DryAire Systems.
6. Honeywell
7. Nautica Dehumidifiers, Inc.
8. PoolPak Technologies Corporation.
9. Thermoplus Air Inc.

2.2 CASINGS

A. Casing: Single-wall construction with corrosion-protective coating and exterior baked-enamel or powder-coated finish, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.

B. Drain Pan and Connection: Plastic

2.3 FANS

A. Supply Fans: Forward curved or Backward inclined, centrifugal; galvanized steel.

2.4 FILTERS

A. Glass Fiber: Minimum 80 percent arrestance according to ASHRAE 52.1, and MERV 5 according to ASHRAE 52.2.

2.5 REFRIGERATION SYSTEM

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.

B. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory fabricated and tested to comply with ASHRAE 33 and ARI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and [**galvanized**] [**stainless**]-steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum 300-psig working-pressure rating and be factory tested to 450 psig and to 300 psig while underwater.

C. Reheat Coil: Hot gas reheat

D. Compressors: Hermetic, rotary compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
   1. Refrigerant: R-410A.

2.6 CONTROLS

A. Comply with requirements in Section 230900 "Instrumentation and Control for HVAC" for control equipment and in Section 230993 "Sequence of Operations for HVAC Controls."

B. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.

C. Building Automation System Interface: Factory-installed hardware and software to enable the building automation system to monitor, control, and display status and alarms.

D. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.

2.7 CAPACITIES AND CHARACTERISTICS

A. As specified on drawings:

2.8 SOURCE QUALITY CONTROL

A. Verification of Performance: Factory test and rate dehumidification units according to ARI 910.

B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to ARI 575.

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. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install dehumidification units on angle iron stands isolated from unit with rubber waffle pads.

3.3 CONNECTIONS

A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum NPS 1-1/4 copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.

D. Duct installation requirements are specified in Section 233113 "Metal Ducts". Drawings indicate the general arrangement of ducts.

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. Perform tests and inspections.

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

C. Tests and Inspections:
1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Dehumidification unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 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.

B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

3.7 CLEANING

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 DEMONSTRATION

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

END OF SECTION 238416

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Cables.
2. Connectors.
3. Solid terminations.
4. Separable insulated connectors.
5. Splice kits.
6. Medium-voltage tapes.
7. Arc-proofing materials.
8. Fault indicators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. General Cable; Prysmian Group North America.
2. Okonite Company (The).
3. Prysmian Cables and Systems; Prysmian Group North America.

4. Southwire Company, LLC.

B. Cable Type: Type MV 105.

C. Conductor Insulation: Crosslinked polyethylene.
1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

D. Conductor: Aluminum.

E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.

F. Conductor Stranding: Compact round, concentric lay, Class B.

G. Strand Filling: Conductor interstices are filled with impermeable compound.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

J. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
2. ABB, Electrification Business.
3. Eaton.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

C. Copper-Conductor Connectors: Aluminum barrel crimped connectors.

2.4 SOLID TERMINATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
2. ABB, Electrification Business.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.

2. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include cold-shrink-rubber sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
2. Eaton.

C. Standard: Comply with IEEE 386.

D. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

E. Load-Break Cable Terminators: Elbow-type units with 200 A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

F. Dead-Break Cable Terminators: Elbow-type unit with 200 A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

G. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless steel mounting brackets, and attaching hardware.
1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

H. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

I. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

A. Description: For splicing medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   2. ABB, Electrification Business.
   3. Eaton.

C. Standard: Comply with IEEE 404.

D. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

2.7 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape for medium voltage application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   2. HellermannTyton.
   3. Scapa Industrial; Scapa Group plc.

C. Ethylene/propylene rubber-based, 30 mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.

D. Silicone rubber-based, 12 mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inch wide.

E. Insulating-putty, 125 mil elastic filler tape. Minimum 1-1/2 inches wide.

2.8 ARC-PROOFING MATERIALS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. 3M.

B. Tape for First Course on Metal Objects: 10 mil thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

C. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, and compatible with cable jacket.

D. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inch on the pull rope.
   1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
   2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
   1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
   3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
   4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. Install "buried-cable" warning tape 12 inch above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

H. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

I. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

J. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

K. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
   2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
   3. Standoff Insulator: At each terminal junction, with one on each terminal.

L. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
   1. Clean cable sheath.
   2. Wrap metallic cable components with 10 mil pipe-wrapping tape.
   3. Smooth surface contours with electrical insulation putty.
   4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
   5. Band arc-proofing tape with two layers of 1 inch wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

M. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

N. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

O. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
   3. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
   4. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

B. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER 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. Section Includes:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alcan Products Corporation; Alcan Cable Division.
   2. Alpha Wire.
   3. Belden Inc.
   4. Encore Wire Corporation.
   5. General Cable Technologies Corporation.
   6. Southwire Incorporated.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

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

1. AFC Cable Systems, Inc.
2. Gardner Bender.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. Ilsco; a branch of Bardes Corporation.
6. NSi Industries LLC.
7. O-Z/Gedney; a brand of the EGS Electrical Group.
8. 3M; Electrical Markets Division.
9. Tyco Electronics.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

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.

3.2 CONDUCTOR INSULATION APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
   2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Test and Inspection Reports: Prepare a written report to record the following:
   1. Procedures used.
   2. Results that comply with requirements.
   3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

D.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Balanced twisted pair cable hardware.
3. Control cable.
4. Control-circuit conductors.
5. Fire-alarm wire and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inch or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.2 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inch. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat black paint. Comply with requirements in Section 099123 "Interior Painting."

2.3 CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One or Multi-pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-CIRCUIT CONDUCTORS

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

1. Encore Wire Corporation.
2. General Cable; Prysmian Group North America.
3. Southwire Company, LLC.

B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

2.5 FIRE-ALARM WIRE AND CABLE

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

1. Allied Wire & Cable Inc.
2. Prysmian Cables and Systems; Prysmian Group North America.
3. Radix Wire.
4. West Penn Wire; brand of Belden, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than size as recommended by system manufacturer and required by NFPA 70.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Control-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Low-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.6 SOURCE QUALITY CONTROL

A. Factory test balanced twisted pair cables according to TIA-568-C.2.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Conduits for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

B. Comply with requirements in Section 260533 "Boxes and Covers for Electrical Systems" for raceway selection and installation requirements for boxes as supplemented or modified in this Section.
1. Outlet boxes must be no smaller than 4 inch square by 2-1/8 inch deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
2. Flexible metal conduit must not be used.

C. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

D. Install manufactured conduit sweeps and long-radius elbows if possible.

E. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inch above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96 inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; cable must not contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and must be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inch from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lay on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.

14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire must be copper, and grounding methods must comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inch above ceilings by cable supports not more than 30 inch apart.
3. Cable must not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For control-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers must use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire must have a unique tag.

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

B. End-to-end cabling will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING 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 grounding and bonding systems and equipment.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning and Grounding.

7. ILSCO.
8. O-Z/Gedney; A Brand of the EGS Electrical Group.
9. Robbins Lightning, Inc.
10. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 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. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

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. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.

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. 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 bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

C. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by 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 Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer 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.
    b. Perform tests by fall-of-potential method according to IEEE 81.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS 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 the following:

1. Hangers and supports for electrical equipment and systems.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. 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:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. ERICO International Corporation.
    d. GS Metals Corp.
    e. Thomas & Betts Corporation.
    f. Unistrut; Atkore International.
    g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

4. 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:

    a. Allied Tube & Conduit.
    b. Cooper B-Line, Inc.
    c. Fabco Plastics Wholesale Limited.
    d. Seasafe, Inc.

5. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
6. Fitting and Accessory Materials: Same as channels and angles.
7. Rated Strength: Selected to suit applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, 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.

    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) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

    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) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

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

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

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 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.

END OF SECTION 260529

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SECTION 260533 - RACEWAYS AND BOXES 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. Metal conduits, tubing, and fittings.
2. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 INFORMATIONAL SUBMITTALS

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

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. Electri-Flex Company.
5. O-Z/Gedney.
6. Picoma Industries.
7. Republic Conduit.
8. Robroy Industries.
9. Southwire Company.
10. Thomas & Betts Corporation.
11. Western Tube and Conduit Corporation.
12. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:
    a. Material: Steel.
    b. Type: Setscrew or compression.
2. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Cooper Technologies Company; Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman.
7. Hubbell Incorporated.
8. Kraloy.
9. Milbank Manufacturing Co.
10. Mono-Systems, Inc.
11. O-Z/Gedney.
12. RACO; Hubbell.
13. Robroy Industries.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

J. Gangable boxes are allowed.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. 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.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 1/2-inch trade size.

D. 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. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew or compression, fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

L. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

M. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

N. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

O. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with 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 according to NFPA 70.

P. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

Q. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

R. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

S. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

T. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

U. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

V. Locate boxes so that cover or plate will not span different building finishes.

W. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

X. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

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SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Type PVC raceways and fittings.
2. Fittings for conduit, tubing, and cable.
3. Solvent cements.
4. Duct accessories.
5. Handholes and boxes for exterior underground wiring.

B. Related Requirements:
1. Section 013100 "Project Management and Coordination" for preinstallation conference procedures.
2. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Duct-bank materials, including spacers and miscellaneous components.
2. Ducts, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes.
4. Underground-line warning tape.

B. Shop Drawings:

1. Precast or Factory-Fabricated Concrete Structures:

a. Include plans, elevations, sections, and details, including attachments to other Work.
b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
c. Include reinforcement details.
d. Include frame and cover design.
e. Include grounding details.
f. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, sumps, and other accessories.

g. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates:

1. For concrete and steel used in precast concrete handholes, as required by ASTM C858.

B. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer.

C. Source Quality-Control Submittals:

1. Source quality-control reports.

1.5 REGULATORY AGENCY APPROVALS

A. Submit Shop Drawings for electric utility duct banks and structures for action by Architect prior to submitting for approval by electric utility.

PART 2 - PRODUCTS

2.1 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651 and UL CCN DZYR.

B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:

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

    a. ABB, Electrification Business.
    b. Calconduit; Atkore International.
    c. JM Eagle.
    d. Topaz Lighting & Electric.

2. Dimensional Specifications: Schedule 40.
3. Options:

    a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
    b. Markings: For use with maximum 90 deg C wire.

2.2 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.

B. Solvent Cements for Type PVC Raceways and Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

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

    a. ABB, Electrification Business.
    b. Allied Tube & Conduit; Atkore International.
    c. Cantex Inc.
    d. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.

B. Underground-Line Warning Tape: In accordance with Section 260553 "Identification for Electrical Systems."

2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:

    a. ASTM C858 for design and manufacturing processes.
    b. SCTE 77.

B. Source Quality Control:

1. Precast Concrete Utility Structures: Test and inspect in accordance with ASTM C1037.
2. Polymer Concrete and Nonconcrete Handhole and Pull-Box Prototypes: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests must be for specified tier ratings of products supplied. Testing machine pressure gages must have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.
    a. Strength tests of complete boxes and covers must be by independent testing agency or manufacturer. Qualified registered professional engineer must certify tests by manufacturer.

C. Precast Concrete Handholes and Boxes:

1. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover must form top of enclosure and must have load rating consistent with that of handhole or box.

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

    a. Oldcastle Infrastructure Inc.; CRH Americas.
    b. Utility Concrete Products, LLC.

3. Configuration: Units must be designed for flush burial and have open or closed bottom unless otherwise indicated.
4. Frame and Cover:
    a. Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
    b. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
    c. Cover Legend: Molded lettering, as indicated for each service.

5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension must provide increased depth of 12 inch.
    b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

6. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at installation location with ground-water level at grade.

7. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus additional 12 inch vertically and horizontally to accommodate alignment variations.
8. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
9. Handholes 12 inch wide by 24 inch long and larger must have inserts for cable racks and pulling-in irons installed before concrete is poured.

D. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover:

1. Description: Molded of sand, concrete, and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or combination.

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

   a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
   b. Oldcastle Infrastructure Inc.; CRH Americas.
   c. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open or closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and installed location.

   a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
   b. Cover Legend: Molded lettering, as indicated for each service.

5. Conduit Entrance Provisions: Conduit-terminating fittings must mate with entering ducts for secure, fixed installation in enclosure wall.
6. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
7. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
8. Options:

   a. Color: Gray or Green.

E. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover:

1. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

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

   a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
   b. Oldcastle Infrastructure Inc.; CRH Americas.

c. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open or closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

   a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
   b. Cover Legend: Molded lettering, as indicated for each service.
5. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
6. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
7. Options:

   a. Color: Gray or Green.

F. Fiberglass Handholes and Boxes:

1. Description: Molded of fiberglass-reinforced polyester resin, with covers made of polymer concrete.

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

   a. Oldcastle Infrastructure Inc.; CRH Americas.
   b. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open or closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

   a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
   b. Cover Legend: Molded lettering, as indicated for each service.
5. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
6. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
7. Options:

   a. Color: Gray or Green.

G. High-Density Polyethylene (HDPE) Boxes:

1. Description: Injection molded of HDPE or copolymer-polypropylene. Cover must be made of polymer concrete.

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

a. Oldcastle Infrastructure Inc.; CRH Americas.
b. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

3. Configuration: Units must be designed for flush burial and have open or closed bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

   a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
   b. Cover Legend: Molded lettering, as indicated for each service.
5. Duct Entrance Provisions: Duct-terminating fittings must be installed perpendicular to box wall and mate with entering duct for secure, fixed installation in enclosure wall without putting stress on box wall or fitting.
6. Options:

   a. Color: Gray or Green.

2.5 UTILITY STRUCTURE ACCESSORIES

A. Description: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

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

1. Oldcastle Infrastructure Inc.; CRH Americas.
2. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.

C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2 inch diameter eye, and 1-by-4 inch bolt.

1. Working Load Embedded in 6 inch, 4000 psi Concrete: 13,000 lbf minimum tension.

D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4 inch diameter eye, rated 2500 lbf minimum tension.

E. Pulling-in and Lifting Irons in Concrete Floors: 7/8 inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; fastened to reinforcing rod; and with exposed triangular opening.

1. Ultimate Yield Strength: 40,000 lbf shear and 60,000 lbf tension.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2 inch ID by 2-3/4 inch deep, flared to 1-1/4 inch minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Ground Rod Sleeve: 3 inch PVC sleeve in manhole floors 2 inch from wall adjacent to, but not underneath, ducts routed from facility.

H. Steel Cable Rack Assembly: Hot-rolled galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form continuous unit; 1-1/2 inch in width by nominal 24 inch long; punched with 14 hook holes on 1-1/2 inch centers for cable-arm attachment.
2. Arms: 1-1/2 inch wide, lengths ranging from 3 inch with 450 lb minimum capacity to 18 inch with 250 lb minimum capacity. Arms must have slots along full length for cable ties and be arranged for secure mounting in horizontal position at vertical locations on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

I. Nonmetallic Cable Rack Assembly: Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inch high by 4 inch wide, with provisions to connect to other sections to form continuous unit, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at locations on cable stanchions, and capable of being locked in position. Arms must be available in lengths ranging from 3 inch with 450 lb minimum capacity to 20 inch with 250 lb minimum capacity. Top of arm must be nominally 4 inch wide, and arm must have slots along full length for cable ties.

J. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater.

2.6 DUCT SEALING

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

1. ABB, Electrification Business.
2. Gardner Bender.
3. Ideal Industries, Inc.
4. NSi Industries LLC.

B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Compound must be capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. Duct sealing compound must be removable without damaging ducts or cables.

C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in field. Notify Architect if there is conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

3.2 SELECTION OF UNDERGROUND DUCTS

A. Duct for Electrical Feeders: PVC-40, direct buried unless otherwise indicated.

B. Duct for Electrical Branch Circuits: PVC-40, direct buried unless otherwise indicated.

3.3 SELECTION OF UNDERGROUND ENCLOSURES

A. Handholes and Boxes:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested in accordance with SCTE 77 with 3000 lbf vertical loading.
5. Cover design load must not exceed load rating of handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Restore area after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in path of underground duct, duct bank, and underground structures in accordance with "Cutting and Patching" Article in Section 017300 "Execution."

3.5 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.
3. Expansion and Deflection Fittings: Install expansion and deflection fitting in each duct in area of disturbed earth adjacent to manhole or handhole.
4. Install expansion fitting near center of straight line duct with calculated expansion of more than 3/4 inch.
5. Curves and Bends:

    a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 12.5 ft, both horizontally and vertically, at other locations unless otherwise indicated.
    b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of 12.5 ft. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.

6. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.

    a. Install insulated grounding bushings on steel raceway terminations that are less than 12 inch below grade or floor level and do not terminate in hubs.

7. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above 104 deg F. Where environmental temperatures are

calculated to rise above 104 deg F, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of 104 deg F.

8. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inch o.c. for 5 inch duct, and vary proportionately for other duct sizes.

    a. Begin change from regular spacing to end-bell spacing 10 ft from end bell, without reducing duct slope and without forming trap in line.
    b. Grout end bells into structure walls from both sides to provide watertight entrances.

9. Duct Terminators for Entrances to Cast-in-Place Manholes and Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inch o.c. for 4 inch duct, and vary proportionately for other duct sizes.

    a. Begin change from regular spacing to terminator spacing 10 ft from terminator, without reducing duct line slope and without forming trap in line.

10. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
11. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.
12. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.

13. Direct-Buried Duct and Duct Bank:

    a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inch in nominal diameter.
    b. Width: Excavate trench 3 inch wider than duct on each side.
    c. Set elevation of top of duct bank below frost line.
    d. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
    e. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
    f. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
    g. Install duct with minimum of 3 inch between ducts for like services and 12 inch between power and communications duct.
    h. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and

contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inch over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

14. Underground-Line Warning Tape for Electrical: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.

15. Underground-Line Warning Tape for Communications: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.
16. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 INSTALLATION OF CONCRETE HANDHOLES AND BOXES

A. Reference Standards:

1. NFPA 70 and NECA NEIS 1.

2. Precast Concrete Handholes: Comply with ASTM C891 unless otherwise indicated.
3. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Precast Concrete Handholes:

   a. Install units level and plumb and with orientation and depth coordinated with connecting duct to minimize bends and deflections required for proper entrances.
   b. Unless otherwise indicated, support units on level bed of crushed stone or gravel graded from 1 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
   c. Field-cut openings for conduits in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

2. Elevations:
   a. Install handholes with bottom below frost line, below grade.

b. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
c. Where indicated, cast handhole cover frame integrally with handhole structure.

3. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
4. Hardware: Install removable hardware, including pulling eyes, cable stanchions,cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
5. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inch for manholes and 2 inch for handholes, for anchor bolts installed in field. Use minimum of two anchors for each cable stanchion.
6. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Reference Standards:

1. NFPA 70 and NECA NEIS 1.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install handholes and boxes with bottom below frost line, below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

7. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Assemble and submit test and inspection reports.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex Company (The).
d. Pipeline Seal and Insulator, Inc.
e. Proco Products, Inc.

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

2.3 SLEEVE-SEAL FITTINGS

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

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

a. Presealed Systems.

2.4 GROUT

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

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

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

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. 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.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install 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.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

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

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

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. Section Includes:

1. Equipment identification labels.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
    b. Outdoor Equipment: Stenciled legend 4 inches high.
    c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Enclosed switches.
f. Enclosed controllers.
g. Variable-speed controllers.
h. Push-button stations.
i. Remote-controlled switches, dimmer modules, and control devices.
j. Battery-inverter units.

END OF SECTION 260553

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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. Lighting and appliance branch-circuit panelboards.

1.3 ACTION 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.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. 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.

C. Panelboard Schedules: For installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

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. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories 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 NEMA PB 1.

D. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.9 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.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's written permission.
3. Comply with NFPA 70E.

1.10 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.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
3. Finishes:

    a. Panels and Trim: Galvanized 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: Same finish as panels and trim.

4. Directory Card: Inside panelboard door, mounted in transparent card holder.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Compression type.
3. Ground Lugs and Bus-Configured Terminators: Compression type.

E. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

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

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
c. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
d. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407.

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 NECA 407.

B. Mount top of trim 90 inches above finished floor unless otherwise indicated.

C. 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.

D. Install overcurrent protective devices and controllers not already factory installed.

E. Install filler plates in unused spaces.

F. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "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 Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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.

D. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electricity metering.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.

1.3 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and utility-furnished components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by the utility company, complying with its requirements.

B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.

1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725.

C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

D. Meter Sockets:

1. Comply with requirements of electrical-power utility company.
2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Arc-Flash Warning Labels:

1. Labels: Comply with requirements for "Arc-Flash Warning Labels" in Section 260573 "Arc-Flash Hazard Analysis." Apply a properly sized self-adhesive label at each work location included in the analysis.

2.3 ELECTRICITY METERS

A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.

B. Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install arc-flash labels as required by NFPA 70.

D. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Minimum conduit size shall be 1/2 inch.

E. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Equipment and Software Setup:

    a. Set meter date and time clock.
    b. Test, calibrate, and connect pulse metering system.
    c. Set and verify billing demand interval for demand meters.
    d. Report settings and calibration results.
    e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.

2. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from the meter reading tests.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262713

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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. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Snap switches and wall-box dimmers.
4. Wall-switch and exterior occupancy sensors.
5. Communications outlets.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 ADMINISTRATIVE REQUIREMENTS

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

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

a. Cooper; 5351 (single), CR5362 (duplex).
b. Hubbell; HBL5351 (single), HBL5352 (duplex).
c. Leviton; 5891 (single), 5352 (duplex).
d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.

3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

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

a. Cooper; VGF20.
b. Hubbell; GFR5352L.
c. Pass & Seymour; 2095.
d. Leviton; 7590.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

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

1) Single Pole:

2) Cooper; AH1221.
3) Hubbell; HBL1221.
4) Leviton; 1221-2.
5) Pass & Seymour; CSB20AC1.

6) Two Pole:

7) Cooper; AH1222.
8) Hubbell; HBL1222.
9) Leviton; 1222-2.
10) Pass & Seymour; CSB20AC2.

11) Three Way:

12) Cooper; AH1223.
13) Hubbell; HBL1223.
14) Leviton; 1223-2.
15) Pass & Seymour; CSB20AC3.

16) Four Way:

17) Cooper; AH1224.
18) Hubbell; HBL1224.
19) Leviton; 1224-2.
20) Pass & Seymour; CSB20AC4.

2.6 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.

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

a. Cooper; 6252.
b. Hubbell; DR15.
c. Leviton; 16252.
d. Pass & Seymour; 26252.

B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, UL 498, and UL 943 Class A.

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

a. Cooper; VGF15.
b. Hubbell; GF15LA.
c. Leviton; 8599.
d. Pass & Seymour; 1594.

C. Toggle Switches, Square Face, 120/277 V, 15 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

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

a. Cooper; 7621 (single pole), 7623 (three way).
b. Hubbell; DS115 (single pole), DS315 (three way).
c. Leviton; 5621-2 (single pole), 5623-2 (three way).
d. Pass & Seymour; 2621 (single pole), 2623 (three way).

2.7 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel.

2.8 PREFABRICATED MULTIOUTLET ASSEMBLIES

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold/Legrand.

B. Description:

1. Two-piece surface metal raceway, with factory-wired multioutlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.

D. Multioutlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: 6 inches.
3. Wiring: No. 12 AWG solid, Type THHN copper, single circuit.
4.

2.9 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by architect.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. 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 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 right 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 devices that have been in temporary use during construction and that 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, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by 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. Install ground pin of vertically mounted receptacles down.

F. 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.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. 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, multigang wall plates.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

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SECTION 262813 - FUSES

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. Cartridge fuses rated 600-V ac and less for use in enclosed switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions and descriptions of individual components. Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Current-limitation curves for fuses with current-limiting characteristics.

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.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, 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 NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

END OF SECTION 262813

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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. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case switches.
4. Enclosures.

1.3 ACTION 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).

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

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: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.6 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.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's written permission.
4. Comply with NFPA 70E.

1.8 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 FUSIBLE SWITCHES

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

B. Type HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
1. Lugs: Mechanical type, suitable for number, size, and conductor material.
2. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

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

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

2.3 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 3R.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

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. Install fuses in fusible devices.

C. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lightning protection system for the following:

1. Ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Qualification Data: For Installer.

C. Product certificates.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Completion Certificate:

1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION FOR STRUCTURES

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

1. East Coast Lightning Equipment Inc.
2. Harger Lightning & Grounding; business of Harger, Inc.
3. National Lightning Protection.
4. Preferred Lightning Protection.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for [Class I buildings.

B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Match existing air terminals unless otherwise indicated.

B. Class I Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.

C. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.

D. Ground Loop Conductor: Stranded copper.

E. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 5/8 inch (16 mm) (19 mm)
3. Rods shall be not less than 120 inches (3050 mm) long.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in NFPA 780.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld.

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 bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

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SECTION 26 51 13 – ARCHITECTURAL LUMINAIRES, SOURCES AND COMPONENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Contract Drawings, conditions of Contract (including General Conditions, Addendum to the General Conditions, Special Conditions, Division 01 Specification Sections and all other Contract Documents) apply to the work of this Section.

B. Related Sections: Division 26

C. Related Appendices Luminaire Schedule and Catalogue Extracts are attached as appendices to this Section.

1.2 SUMMARY

A. Included in the Work of this Section are labor, materials, and appurtenances required to complete the Work of this Section, as specified herein, as required by job conditions, or as indicated on drawings. The scope of this section includes general requirements for luminaires and their components, coordination, definitions, quality assurances, submittals, mockups, samples and general responsibility for a complete job.

1.3 DEFINITIONS

A. In this specification, the term "Architect" includes the Architect, Interior Designer, Landscape Architect, Construction Manager, Owner's representative and/or the Lighting Specifier, together or individually as they shall decide.

B. The term "luminaires" refers to lighting fixtures with their integrated light sources and all other components.

C. The use of the word "Approved" shall not extend the Architect's responsibilities beyond that as defined in the General Conditions.

1.4 GENERAL REQUIREMENTS

A. Provide labor, materials, and equipment for the installation of indoor and outdoor luminaires, lighting equipment, control wiring, and sources as shown on the drawings and specified herein and in Related Sections. Luminaires shall be securely attached to supports.

B. Refer to architectural drawings for locations, dimensions and details, and electrical documents for quantities. Check and verify dimensions and details on drawings before proceeding with the Work. Report any inconsistencies or discrepancies. Should it appear that the Work intended is

not sufficiently detailed or explained on the drawings or in the specifications, apply for further drawings or explanations, as may be necessary. Conform to these explanations in the work. If any question arises about the true meaning of the drawings or specifications, provide timely and written questions before proceeding. Under no circumstances shall any request for extra compensation be honored where the basis of claim is such a clarification. In no case submit a bid or proceed on any Work with uncertainty. The intention of this specification and the accompanying or applicable drawings is to provide a job complete in every respect. Contractor is responsible for this result.

1.5 COORDINATION

A. Luminaire locations and mounting heights as indicated on the electrical drawings are generalized and approximate. Carefully verify locations and mounting heights with Architect's drawings, reflected ceiling plans, interior elevations and other reference data prior to installation. Check for adequacy of headroom and non-interference with other equipment, such as ducts, pipes or openings. Provide timely and written notification of such conflicts before proceeding with the Work. Although the location of equipment included in the Work of this Section may be shown on the Contract Drawings in a certain place, actual construction may disclose that the location for the Work does not make its position easily and quickly accessible. In such cases, provide timely and written notification of this situation before installing this Work, and comply with installation directions.

B. Clearly indicate the Work to be performed by other trades' contractors, and the materials that are adjacent to or abutting the Work of this Section. Coordinate as required. Give ample notice of special openings required for placing equipment in the building, in order to avoid cutting of completed Work. Provide the materials and labor for Work included under this Section in ample time, and in sufficient quantities so that all of the Work may be installed in proper sequence to avoid unnecessary cutting of the floors and walls. Schedule the Work to prevent Work of this Section being damaged by other construction operations. Remove and replace Work so damaged at no cost to the project. Coordinate and schedule the Work of this Section with the Work of other Sections and Utility Companies so that there shall be no delay in the proper installation and completion of any part of each respective Work. Construction Work shall proceed in its natural sequence without unnecessary delay caused by the Work of this Section.

C. Coordinate with other contractors regarding attachment to or openings in the materials of other trades such as pre-cast concrete, ornamental metals, or wood panels for recessed junction boxes, and other equipment.

D. Arrange the installation in proper relation to other Work and with architectural finishes so that it shall harmonize in service and appearance and so that there shall be no interference with the Work of others, including interference in location or level.

E. Where a catalog number and a narrative or pictorial description are provided, the written description shall take precedence and prevail.

F. Where Work of this Section is to be flush or concealed, install it to assure that it does not project visually or physically beyond the finished lines of floors, ceilings or walls.

G. Verify ceiling conditions and provide appropriate mounting details for each luminaire. Submit mounting details for approval.

H. Become familiarized with all equipment listed in the luminaire schedule and take responsibility for the successful completion of the entire lighting installation.

I. Verify compatibility of supply voltage indicated on electrical drawings with voltage specified for each luminaire prior to release. Provide timely and written notification of any and all discrepancies.

J. (Exhibit) The qualities, types and mounting of luminaires form the basis of the scope and complexity of the work. Locations of luminaires, especially in the exhibit areas, are approximate until the exhibit designs are complete. If locations change, clarification drawings will be issued no later than the end of the shop drawing phase showing revised locations in three dimensions and/or revised control zone designations. If there are not changes in type, quantity, or mounting difficulty, these changes shall not constitute a change in scope or add cost to the job. Verity receipt of final information before release of luminaires or installation.

1.6 QUALITY ASSURANCES

A. Contractor shall comply with the General Requirements related to Quality Control, in addition to the provisions herein.

B. Manufacturers: Manufacturers listed in the APPENDIX – LUMINAIRE SCHEDULE (lighting fixture schedule) herein, shall be assumed capable of supplying the listed luminaires unless exceptions are set forth in their quotations. Provide timely and written notification of any such exceptions. Acceptable manufacturers are listed in the luminaire schedule. Acceptable manufacturers shall be capable of providing proof of satisfactory production of luminaires of the type and quality shown for a period of at least five years.

C. Statement of Application:
   1. By commencing the Work of this Section, the Contractor assumes overall responsibility, as a part of the warranty of the Work, to ensure that assemblies, components and parts shown or required within the Work of this Section, comply with the Contract Documents.
   2. Warranty: In addition to any warranties required by the General Requirements, the Contractor of the Work of this section shall:
      a. For a period of one year after Owner's initial acceptance and establishment of the beginning date of the warranty period, and at no additional cost, promptly provide and install replacements for luminaires or components thereof which are defective in materials or workmanship under normal operating conditions, except for sources; or successfully repair installed equipment at the job site. For any time during the warranty period that luminaires are not fully functional due to defects in materials or workmanship, provide or pay for and install and remove suitable and adequate temporary luminaires. Warrant replacement luminaires or components to be free of defects in workmanship or materials for a period of one year following replacement and replace any defective replacements.
      b. Contractor shall not be held responsible for acts of vandalism or for abnormal or accidental abuse of the luminaires or their components occurring after the beginning of the warranty period, nor shall Contractor be held responsible for deleterious

effects caused by maintenance procedures performed without the concurrence of Contractor.

D. Equipment Compatibility:
   1. For all similar luminaire type, provide luminaires, power supplies, LED drivers, ballasts and other components fabricated or supplied by a single manufacturer, to simplify maintenance and replacement of equipment. Under no circumstances shall sources of the same type, even if different wattages, be supplied by more than one manufacturer unless operable samples are submitted, reviewed and approved in writing.
   2. Luminaire details shown may be modified by the manufacturer provided all of the following conditions have been met:
      a. Luminaire performance is equal or improved.
      b. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
      c. Cost to the Owner is reduced or equal.
      d. No conformance to codes has been compromised.
      e. No performance criteria for, LEED, or WELL Building ratings has been compromised.
      f. Modifications have been reviewed and approved in writing.

E. Regulatory Agencies:
   1. Provide luminaires constructed, wired and installed in compliance with the current edition of applicable city, state and national codes. Provide luminaires conforming to or exceeding Underwriters Laboratories (UL) standards, and to provisions of applicable codes which exceed those standards.
   2. For any category of luminaire tested by any of the following labs, provide luminaires listed and labeled by an independent Nationally Recognized Testing Laboratory (NRTL) such as UL, ETL, CSA, MET
   3. In addition, provide luminaires which conform to additional regulations necessary to obtain approval for use of specified luminaires in locations shown. Use only electrical components listed by the above NRTLs.

F. Recognized Standards: In addition to standards that may be referenced in Division 01 Specification Sections, luminaires shall comply with the applicable standards of the following organizations.
   1. Underwriters Laboratories (UL)
   2. National Electrical Code (NEC)
   3. Certified Ballast Manufacturers Association (CBM)
   4. Illuminating Engineering Society (IES)
   5. American Society for Testing and Materials (ASTM)
   6. American National Standards Institute (ANSI)
   7. National Electrical Manufacturers Association (NEMA)
   8. International Electrotechnical Commission (IEC)
   9. National Electrical Safety Code (IEEE C2)
   10. Americans with Disabilities Act (ADA)
   11. Intertek (ETL)
   12. Canadian Standards Organization – US (CSA-US)

1.7 BIDDING

A. Follow bidding procedures as described in Division 01 of this specification.

B. Provide specified and alternate unit prices separated from installation costs as required in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule).

1.8 SUBSTITUTIONS:

A. Luminaires included under this Section are specified by approved manufacturer and type. Provide equipment exactly as specified, unless substitutions are mutually agreed upon, as follows:
   1. Any proposed substitutions must be accompanied by full point-by-point calculations and auxiliary documentation demonstrating that the proposed luminaires fully meet the criteria in each specific application.
   2. Substitutions will only be considered for luminaire descriptions where the words "or approved equal" are explicitly stated.
   3. Substitutions shall not be considered that may compromise the performance criteria for LEED, WELL Building or other project requirements. If impact is not clear, submit verification and/or calculations or manufacturers data demonstrating equivalent performance.
   4. Submit a written request for luminaires proposed for substitution, at least two weeks before the end of bid period – the “substitution period”. Make the request for substitution an alternate, separate proposal, accompanied by complete descriptive and technical data. Indicate if there is any addition or deduction from the base bid. Substitutions proposed after this time, or not including proper documentation shall not be considered. Submissions of substitutions may be accepted or rejected without explanation.
   5. Exceptions: During the construction period, no substitutions shall be considered unless compelling reasons are given - such as a specified product no longer being available. If Contractor has failed to follow the schedule presented under the Paragraph titled "Submittals" below, no substitutions will be allowed based on inability of specified manufacturer to meet delivery schedule, and the Contractor shall provide luminaires exactly as specified without delay to the project and without additional cost to Owner.
   6. Substitutions shall be indicated as such in the bid documents, and operable (plug-in) samples, catalogue cuts and complete photometric reports by independent testing laboratories submitted. A complete comparison of the performance of the proposed substitution in relation to the performance of the first named specified product shall be included. In addition, for any luminaire type of which six (6) or more of the luminaires are to be used, submit computer generated point-by-point calculations for illumination on vertical and horizontal planes. Such calculations shall include either the typical mounting condition for the subject luminaire or a specialized mounting condition deemed critical for the success of the design.
   7. Written documentation shall clearly show that the proposed manufacturer complies with each and every aspect of the specification and/or indicate any exceptions or variations. Where proposed substitutions alter the functional or visual design or change the space requirements or mounting details indicated herein or on the drawings, such changes shall be detailed in the proposal and costs indicated for revised design and construction for trades involved. Cost data shall be provided as called for in the General Requirements. Submittal

shall include names and addresses of at least three (3) similar projects on which the product was used, including names and phone numbers of specifiers and owners of each project, and dates of installation.

B. Value Engineering:
1. To the extent that Value Engineering is allowed in the General Requirements, the procedure for value engineering is the same as outlined above regarding the substitution process, with the words "value engineering proposed substitution(s)" replacing the word "substitution(s)". Value engineering submittals shall be clearly separated from substitutions, and line-item cost savings for each proposed luminaire type clearly documented.

1.9 SUBMITTALS

A. General:
1. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer which clearly show all elements to be supplied and all corresponding product data (including sources, manufacturer and model number of power supply, LED driver, ballast, and other components, as well as voltage; accessories, options and any miscellaneous items detailed in the written description of the specification.) If cut sheet shows more than one (1) luminaire type, all non-applicable information shall be crossed out.
2. For custom luminaires, modified luminaires or linear luminaires mounted in continuous rows, submit a layout drawing prepared by the manufacturer showing all details of construction, lengths of runs, source layout, if applicable, suspension installation hardware or components, power locations, remote power supplies, remote LED drivers, remote transformers, finishes and list of materials. Drawings must be to scale. Provide manufacturer with field dimensions where required. If scallop shields, wallwash reflectors or baffles are required, drawings shall indicate relative position to wall or adjacent vertical surface.
3. When components are indicated as contractor supplied or specified (i.e. remote power supplies, remote LED drivers, ballast housings, NEMA enclosures, etc., provide submittals for components in conjunction with the luminaire submittal.
4. Provide submittals with luminaire installation instruction sheets.

B. Submittal Schedule (Note: All days, week or months listed are "calendar" days, weeks or months, and not working days, weeks or months):
1. List of Intended Manufacturers: Within fifteen (15) calendar days of the Notice to Proceed, submit a List of Intended Manufacturers, with estimated fabrication lead times. "Lead times" shall be measured in weeks, beginning from the manufacturer's receipt of approved shop drawings and release, and ending at shipment. The response to this list will indicate if any manufacturers are unacceptable.
2. Acknowledgments and standard shop drawings: Within twenty (20) days after receipt of the response to the list of Intended Manufacturers, submit copies of purchase orders and manufacturers' acknowledgments for all luminaires specified, conforming to responses. The purchase orders and the manufacturer’s acknowledgments need not list prices, but shall contain a guaranteed fabrication lead time, in weeks, as defined above. These fabrication times shall be adequate for the timely completion of the job. At the same time, but not less

than twenty-four (24) weeks before standard manufactured luminaires are required on the site, submit shop drawings for all standard luminaires or those with minor modifications.

3. Custom Shop Drawings: In order to allow for mockups and independent testing for all custom luminaires or those with major modifications, submit complete shop drawings within sixty (60) days after the Notice to Proceed, but not less than eleven (11) months prior to the time they are required on the site.
4. Release for fabrication: Within twenty (20) days after receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted", release luminaires for fabrication and forward verification that the luminaires have been released for fabrication, with a guaranteed shipment date for each specified luminaire. At the same time, forward finish or component samples, tests, or any outstanding data required for approval.
5. Operable luminaire samples and mockups as indicated in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule) shall be received by the designated parties, or installed on the site, within forty-five (45) days after Contractor's receipt of shop drawings marked "No Exceptions Taken" or "Make Corrections Noted".
6. Re-submissions: Within fourteen (14) days after receipt of shop drawings marked "Revise and Resubmit" or "Rejected", resubmit revised shop drawings in accordance with the General Requirements regarding re-submissions.
7. Provide written notification of any potential scheduling problems, or of any submittals that have not been returned which are required to maintain the installation schedule. Such notification shall be in a timely manner and well in advance of the time such delay might affect the fabrication schedule or appropriate delivery of luminaires.
8. Request for Final Layout: At the same time that shop drawings are submitted, request verification of final layouts and control zones for all luminaires. Submit templates for labeling of all controls. Layout adjustments shall be considered no-cost clarification as long as the quantity or value of luminaires does not increase. Provide blank control station faceplates until labels are available. Custom engraved or labeled faceplates shall be ordered from the manufacturer so that they arrive prior to the final release of the space and subsequent beginning of the warranty period. Blank faceplates shall be replaced with custom labeled faceplates at no additional cost to the project.

C. Shop Drawings:
1. Submit shop drawings for each type of luminaire, arranged in order of lighting type designation except where specified luminaires are standard, unmodified, "off-the-shelf" units, fully described by catalogue cuts. If comprehensive, such catalogue cuts may be substituted for shop drawings, however full shop drawing shall be submitted upon request. Submit catalogue cuts of individual lamps or replaceable source modules to be provided for each luminaire. Submit shop drawings in the quantity and format called for in the General Requirements.
2. Shop drawings shall show all luminaire components, including but not limited to lampholders, reflectors, louvers, lenses, fuses, junction boxes, power supplies, ballasts and sources. Shop drawings shall show materials, finishes, metal gauges, overall and detailed dimensions, sizes, electrical and mechanical connections, fasteners, welds, joints, any exposed hardware, and conditions, or provisions for the work of others, and similar information. Indicate complete details of the luminaire, including manufacturer's name and catalogue numbers for sockets, power supplies, LED drivers, ballasts, light shields, switches and type of wiring, and targeting and locking devices for adjustable luminaires. Indicate that source type specified is appropriate for luminaire design. Indicate maximum allowed distance between light luminaire and remote power supply. Indicate type and

extent of approved inert insulating materials to prevent electrolytic corrosion at junctions of dissimilar metals. Include pertinent mounting details including hung ceiling construction. Standard catalogue cuts shall be supplemented by additional drawings if information or descriptions listed above are not included in the cuts. Photometric documentation and finish samples shall be provided upon request. Samples shall be provided if indicated in APPENDIX - LUMINAIRE SCHEDULE (the lighting fixture schedule). No luminaires will be approved without the previous described submission of data. Submissions may be modified during the submission review process. Luminaires or other materials shall not be fabricated, shipped, stored or installed unless prior written approval has been received.

3. Submit layouts for continuous luminaires or coves, indicating overall field measurements and proposed lengths, and condition of joints, corners, ends and any unlighted lengths.
4. Submit catalogue cuts for all lamps, power supplies, LED drivers, ballasts and emergency battery backup power supplies and ballasts.

D. Data: Submit independent laboratory photometric data in the directed number of copies and in format as directed. Photometric data shall be submitted for standard, "off-the-shelf" units at the time the manufacturer's cuts are submitted. Photometric testing and reporting shall conform to IESNA procedures. Submit additional photometric testing as required by Luminaire Schedule or upon request.

E. Manufacturer's Catalogue Sheets shall indicate input watts and electrical characteristics, ambient temperature rating, noise level rating, mounting methods and UL or ETL listing for use with required source, power supply, LED driver, transformer, lamp and/or ballast (if any).

1.10 SAMPLES

A. After shop drawings, data and any other required submissions have been approved, submit samples of each of the following components upon request:
1. Samples demonstrating the finishes of any custom metal, paint color or finish. Sample size to be a minimum of 4in (100mm) square. Place labels on the back side of finish samples only.
2. Material samples of any transmitting media, such as plastic, glass, perforated metal and the like. Sample size to be a minimum of 12in (305mm) square, to allow adequate space for label.
3. Each downlight reflector cone that differs in size or finish.
4. Any other luminaires or components requested in the luminaire descriptions, schedule, or in the contract documents.

B. Submit two (2) samples unless otherwise indicated. If luminaire samples are requested, supply a completely operable luminaire as specified in the Luminaire Schedule and/or incorporating responses to shop drawing, with the specified source and a 10ft (3m) cord and plug for standard 120-volt service. For 277-volt luminaires, also supply a completely wired or plug-wired step-up transformer to convert from 120 to 277 volts, with a 120-volt cord and plug. Provide component parts as specifically requested.

C. Where a sample is submitted or requested, do not fabricate that luminaire type until the sample is approved. Submit and resubmit a sample as required, until samples are approved.

D. The purpose of the sample is to review manufacturing techniques, detailing, light source, and scale. Minor modifications, if any, shall be considered part of these Specifications and shall be accomplished at no additional cost.

E. Submit complete and operable sample luminaires for any proposed substitution or value engineering proposal as indicated above. There shall be no expectation that substitution products or samples received after the substitution period will be accepted or reviewed.

F. Provide samples as called for in the General Requirements. Tag samples with the name of the project, referenced specification, paragraph or drawing number, the luminaire type number and any other identifying data. Ship the samples to two separate addresses as requested. After review, the samples shall be shipped to the project site for use as standards. All transportation charges for samples shall be paid by Contractor. Make luminaires supplied under the Work of this Section identical with approved samples. Do not install any sample luminaires in the project.

G. If sample submissions are not approved, samples shall be returned to Contractor, at Contractor's expense. Upon receipt of sample disapproval, immediately make a new submission of samples meeting the comments and contract requirements, as called for in the General Requirements.

1.11 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Luminaires and their component elements shall be delivered to the job site factory-assembled and wired to the greatest extent practical, in strict accordance with the approved shop drawings, samples, certificates and catalogue cuts, and shall be handled in a careful manner to avoid damage.

B. Exposed finishes shall be protected during fabrication, transport, storage and handling. Delivered materials shall be identical to the approved samples. Materials which become damaged shall be repaired and/or replaced as directed.

C. Luminaires shall be stored under cover, above the ground, in clean, dry areas, and shall be tagged and/or marked as to type and location.

D. Delivered luminaires shall include wiring, sockets, power supplies, LED drivers, ballasts, shielding, channels, lenses and other parts and appurtenances necessary for luminaire installation of each luminaire type.

E. Protect luminaires that are to be integrated into, or finally located after completion of exhibit construction work.

1.12 MOCK-UP

A. As a part of the Work of this Section, when specifically called for in the Luminaire Schedule, and at no additional cost to project, temporarily install, connect and adjust a reasonable number of luminaires, three (3) unless otherwise stated. Install completely operable luminaires with all sources, power supplies, LED drivers, ballasts, etc., of each type listed in the Luminaire Schedule where a mock-up is specified, to verify the specified catalogue number and requirements. Place the mock-up luminaires where and when directed. Remove and store mock-up luminaires, when approved, as necessary to complete the work, at Contractor's expense.

1. The mock-up installation shall closely conform to the conditions of the actual installation as to height, distance from ceiling, light source type, output and performance, number and type of sources, material, color, and space finishes, etc. Submit a written description of each proposed mock-up with drawings to obtain approval prior to commencement of each mock-up.
2. Where mounting of mockup may negatively impact existing conditions or constructed scope of Work, temporary mounting methods shall be implemented to avoid any damage.
3. The purpose of the mock-up will be to study the general appearance and performance of the intended lighting systems unless otherwise indicated. At that time, certain minimal test variations may be requested as to lamp location, source type, reflector shape, color, etc. Final modifications, if any, shall be considered as part of these Specifications and shall be accomplished with no additional cost to the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide materials, equipment, appurtenances and workmanship for the Work of this Section conforming to the highest commercial standards, as specified and indicated on the drawings. Make luminaire parts and components not specifically identified or indicated on the drawings, of materials most appropriate to their use or function, and resistant to corrosion and to thermal and mechanical stresses encountered in the normal application and function of the luminaires.

B. Provide recessed luminaires that are constructed to be suitable for and compatible with the ceiling, wall, pavement or other materials and construction in which they will be installed.

C. Named manufacturers, when listed in the luminaire schedule, are representative of an adequate level of quality and reputation, and are allowed to submit a product, provided that they are capable of satisfying the provisions of the specifications in every respect. This does not mean that any standard product provided by that manufacturer is automatically qualified. Manufacturers not on this list may be proposed during the substitution period if they can substantiate that their product meets every particular of the relevant specification, and are of comparable quality, experience and reputation. See the paragraph titled "Substitutions", above. Any submitted product may be rejected without explanation.

2.2 DEFINITIONS:

A. CCT: Correlated Color Temperature

B. CRI: Color Rendering Index

C. Fixture: See “Luminaire”

D. IP: International Protection or Ingress Protection Rating

E. LED: Light Emitting Diode

F. Lumen: Measured output of source and luminaire or both

G. Luminaire: Complete lighting unit, including source, gear, reflector and housing

2.3 MARKING OF LUMINAIRES

A. Luminaires shall be equipped with markings showing safety specifications, construction safeguards, and minimum resistance to hazard sources operation under fault conditions. Marking shall include manufacturer/distributor's name, related voltage or voltage range, rated wattage, light output, optical distribution and rated frequency. LED luminaires not suitable for dimming control are required to indicate this clearly in installation instructions or package labelling. Mark luminaires with replaceable sources according to proper source type. Provide markings that are clear and that are located to be readily visible to service personnel, but invisible from normal viewing angles when sources are in place.

2.4 MATERIALS AND FABRICATION

A. Provide luminaires completely factory-assembled and wired and equipped with necessary sockets, power supplies, LED drivers, ballasts, wiring, shielding, reflectors, channels, lenses, integral emergency battery packs (if required) and other parts and appurtenances necessary. Deliver to project site ready for installation and to complete the luminaire installation.

B. Use only completely concealed hardware, unless otherwise noted. Latching of luminaire door frames shall be unobtrusive. Make luminaire free from light leaks by the inherent design of the luminaire body and frame. Bond gaskets, when used, to the luminaire metal. Weld power supply support studs, socket saddle studs and reflector support studs to luminaire body. Flexible leads shall enter luminaires at sides, unless otherwise noted.

C. Minimum gauges sheet steel: 22-gauge for recessed LED unless thicker gauge required by regulating agency.

D. Construct luminaires with the minimum number of joints. Make unexposed joints by approved method such as welding, brazing, screwing or bolting. Soldered joints are not acceptable.

E. Provide metallic cast or extruded parts of luminaires that are close grained, sound, and free from imperfections or discoloration. Provide cast or extruded parts that are rigid, true to pattern, and of ample weight and thickness. Provide cast or extruded parts that are properly fitted, filed, ground, and buffed finished surfaces and joints free of imperfections. Make thickness on cast parts not less than 1/8in (3mm).

F. Provide housings that make electrical components easily accessible and replaceable, without removing the luminaire body from its mounting.

G. Provide luminaires indicated as "continuous" on drawings or specifications with finished end-to-end or wall-to-wall appearance. Verify run lengths per field conditions prior to ordering. Maximize lighted length to nearest six inches (152mm), with equally spaced unlighted portions at each end, not to exceed 3 inches (76mm) each. Provide continuous louvers and/or lenses into unlighted ends and at corners.

H. Wiring:
1. Provide luminaire wiring between sources, lampholders and associated operating and starting equipment in compliance with UL 1570 and NEC, UL 8750 for LED's.
2. Make connections of wires to terminals of sources, lampholders and other accessories in a neat and workmanlike manner and which are electrically and mechanically secure, with no loose strands protruding. Provide of the appropriate amount of wires extending to or from the terminals of a source, lampholder or other accessory. These wires shall not be in excess of the number which the accessory is designed to accommodate.
3. Provide wiring channels and wireways free from projections and rough or sharp edges throughout. At points or edges over which conductors shall pass and may be subject to injury or wear, grind to make a smooth contact surface with the conductors. Install insulated bushings at points of entrances and exit of flexible wiring.

I. All interior luminaires shall be UL/ETL/CSA-US listed, "Damp Location" rated at a minimum, with greater protection (UL/ETL/CSA-US "Damp Location" or "Wet Location") as appropriate or required by code for the application.

J. All exterior luminaires shall be UL/ETL/CSA-US listed, "Wet Location" rated at a minimum (unless otherwise specified). All hardware, including bolts embedded in lighting pole foundations, shall be stainless steel or equivalent marine grade resistant.

2.5 FINISHES

A. The paint finish/color may affect the heat dissipation from luminaires. Apply luminaire finishes after fabrication in a manner that assures a durable wear-resistant surfacing. Prior to finishing, hot clean the surfaces by accepted chemical means, and treat them with corrosion inhibiting (phosphating) treatment to assure positive paint-adhesion. Give exposed metal surfaces (brass, bronze, aluminum and others) and finished castings except chromium-plated or stainless-steel parts an even coat of high-grade methacrylate lacquer, or transparent epoxy. Anodize exposed aluminum surfaces for corrosion resistance. Make sheet steel luminaire housing, and iron and steel parts which have not received phosphating treatment, or which are to be utilized in exterior applications corrosion resistant by zinc or cadmium plating or hot-dip zinc galvanizing after completion of all forming, welding, or drilling operations.

B. Electroplate parts operated under temperatures injurious to hot-dipped galvanizing.

C. Cadmium plate screws, bolts, nuts and other fastening or latching hardware.

D. Except where otherwise indicated provide luminaires with a final synthetic, high-temperature baked enamel coating of color and finish as specified or directed. Unless otherwise specified, provide white baked enamel "reflective" surfaces, with a minimum reflectance of 86 percent. Unless otherwise specified, provide potentially visible non-reflective surfaces with a matte-black baked enamel finish. Prior to painting give all parts proper etched surface preparation to assure paint adherence and durability.

2.6 COMPONENTS

A. General:

1. Provide identical power supply and gear within each luminaire type. Provide power supplies and gear that are suitable and UL-listed for the electrical characteristics of the supply circuits to which they are to be connected and which are suitable for operating LED or relevant light sources, including future LED replacement lamps.
2. Unless otherwise specified, provide power supplies and control gear of same type and same manufacturer for ease of stocking and replacement.
3. Components shall be configured and installed in luminaire by the luminaire manufacturer.
4. Components shall not contain Polychlorinated biphenyls (PCBs) and shall be labeled “No PCBs”.
5. Gear housing shall be constructed of painted metal with no sharp edges.
6. Provide only luminaires whose design, fabrication and assembly prevent overheating or cycling of light engines or power supplies under any condition of use.
7. Electronic ballasts shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, Part C (RF Lighting Devices) Non-consumer equipment, regarding radio frequency interference (RFI) (radiated) and electromagnetic interference (EMI) (power line conducted).
8. Submit gear details with luminaire shop drawings.

B. LED Emergency Lighting:

1. Where emergency illumination is provided by one or more directly controlled luminaires (An emergency luminaire that has a control input for an integral dimming or switching function that drives the luminaire to full illumination upon loss of normal power) that respond to an external control input to bypass normal control upon loss of normal power, such luminaires and external bypass controls shall be individually UL924 rating listed for use in emergency systems.

2.7 TRANSFORMERS FOR LOW-VOLTAGE LUMINAIRES

A. General:
1. Each transformer controlled by a dimmer shall have a suitable choke to eliminate noise during dimming.
2. Secondary wiring shall meet all requirements of this Division and of all applicable local codes. Additionally, secondary wiring shall be sized so that the total average voltage drop on the transformer secondary side does not exceed 3 percent.
3. Source operating voltage, as measured at the socket, shall be between 11.5-12.1 volt for nominal 12-volt sources, and between 23.0-24.2 volt for nominal 24-volt sources. Contractor shall demonstrate that voltage is within this range if requested.

B. Where a remote transformer is required for interior installations, provide a UL listed remote low voltage power supply which meets or exceeds the following requirements, in addition to those of Paragraph A above.
1. Power supply shall contain a toroidal transformer, primary circuit breaker, and thermal protection.
2. Power supply shall be UL listed, suitable for surface or recessed mounting in both walls and ceilings and require zero clearance to combustible materials.

2.8 SOURCES

A. General:
   1. Provide electric sources as required, during construction, including sources for luminaires provided by others.
   2. Provide a complete set of new lamps (excluding LED lamps and light engines), as described in this Section and specified the Luminaire Schedule below, in each luminaire, at the completion of the Work, leaving luminaires and lighting equipment completely lamped and/or in normal operating condition. Provide spare sources in accordance with the paragraph titled “Spares”, below.
   3. Submit catalogue cuts of all sources to be used in the Work, along with the shop drawing submittal.

B. Solid State Lighting / Light Emitting Diode (LED) Light Sources and Luminaires:
   1. General:
      a. 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) North American installations.
      b. Unless otherwise specified, luminaire fabrication shall integrate all LED light sources and power/data supplies fabricated by a single manufacturer to ensure compatibility.
      c. All components peripheral devices, integrated photosensors, occupancy/vacancy sensors, controllers, even if manufactured or provided by others, shall be the responsibility of a single entity, the luminaire manufacturer. All components shall perform successfully as a complete system. Integrated controls shall be programmed onsite to operate as described in Lighting Control Intent Narrative documents or Appendix - Luminaire Schedule.
      d. Provide submittals as described in Part 1 above.
      e. Provide two (2) samples of each separate manufacturer and type of LED luminaire if requested in Appendix - Luminaire Schedule. Follow procedure for submitting samples as described in Part 1 above.
      f. Include all components necessary for a complete installation. Provide all power supplies, synchronizers, data cables, and data terminators for a complete working system.
      g. All white light LED sources within the same luminaire type shall be within two (2) MacAdam ellipses/steps of each other.
      h. All LED sources used in the LED luminaire shall be of proven quality from established and reputable LED manufacturers and shall have been fabricated within 12 months before installation per the date code on the module. Acceptable LED component or module manufacturers unless otherwise noted are:
         1) Cree, Inc.
         2) Lumileds
         3) Nichia Corporation
         4) Norlux
         5) Lextar
         6) Osram Optronic Semiconductors
         7) Xicato
         8) Bridgelux
         9) Epistar

10) San'an
11) Citizen Electronics
12) General Electric Company
13) Soraa
14) Samsung
15) Seoul Semiconductor
16) Lumenetix
17) Ledengin

2. Replacement and Spares:
   a. Manufacturer shall provide written guarantee of the following:
      1) Manufacturer's LED system or equivalent system will be available for ten (10) years: Manufacturer will provide exact replacement parts, complete replacement luminaires, 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) Manufacturer will keep record of original chromaticity coordinates for each LED module and have replacement modules or luminaires from within two (2) MacAdam Ellipses/ steps of the same coordinates available.
      3) Manufacturer will keep an inventory or ability to supply replacement parts or complete fixtures within two (2) weeks for component parts or the standard lead time of the original fixture for a complete fixture for duration of warranty period.
   b. All parts of system shall be replaceable in the field as specified in Appendix - Luminaire Schedule.
   c. System shall carry a full warranty for a minimum of three (3) years from the date of shipment (or longer if required by the project, also refer to Division 1 – General Requirements for further warranty requirements).
3. Products and Components – Performance
   a. LED luminaires and components shall be approved by an NRTL facility such as UL, ETL or CSA/US.
   b. For applicable fixtures: 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.
   c. All LED components shall be mercury and lead-free.
   d. All manufacturing processes and electronic 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.
   e. LEDs shall comply with ANSI/NEMA/ANSLG C78.377-2008 – Specifications for the Chromaticity of Solid-State Lighting Products. Color shall remain stable throughout the life of the source. The chromaticity of the installed product shall match IES LM-80 data showing that the LED's do not shift more than .005 DuV from an approved sample or submitted documentation.
   f. LEDs testing shall be performed in accordance with IES LM-80 - Approved Method for Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.
   g. LEDs shall have a minimum rated source life of 50,000 hours or as specified in Appendix: Luminaire Schedule. LED "rated source life" shall be determined per IES TM-21 - Projecting Long Term Lumen Maintenance of LED Light Sources based

on LM-80 test data. Calculated lifetimes not exceeding testing hours per TM-21 are not accepted.

h. Luminaire assembly shall include a method of dissipating heat to prevent degradation of source life, 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. 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

i. Luminaire shall be tested and suitable to operate under a minimum of two (2) case temperatures: 55°C (131°F) and 85°C (185°F) and a relative humidity under 65%.

j. Manufacturer shall supply in writing a range of permissible operating temperatures and relative humidity levels in which system will perform optimally. LEDs shall be adequately protected from moisture or dust in interior applications.

k. All hardwired power connections to LED luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed, shorted or otherwise mis-wired during the installation process.

l. LEDs shall not be overdriven beyond their specified nominal voltage and current.

m. Manufacturer shall be able to provide supporting documentation of the product meeting third party regulatory compliance.

n. Manufacturer shall ensure that products undergo and successfully meet appropriate design and manufacturability testing including Design Failure Mode & Effects Analysis, Process Failure Mode & Effects Analysis, Environmental Engineering Considerations and Laboratory Tests, IEC standards and UL/CE testing.

o. 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 testing standards IES LM-79-08 and IES LM-82-12, based on test results from an independent Nationally Recognized Testing Laboratory or National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory.

4. All color characteristics, CCT, CRI, Color Fidelity, CIE Chromaticity Coordinates shall be consistent across the entire dimming range.

5. Luminaires shall have less than 30% flicker at frequencies of 200Hz or below at 100% and 20% light output and/or meet IEEE standard PAR 1789.

C. LED Power Supplies/ Drivers:

1. LED driver shall have a minimum 50,000 hour published life while operating at maximum case temperature and 65 percent non-condensing relative humidity.

2. Driver shall be Sound Rated A+.

3. Driver shall be > 80% efficient at full load across all input voltages.

4. Driver shall include ability to turn off at low control input rather than holding at a minimum dimming level and shall consume 0.5 Watts or less in standby/off mode. Control deadband at low control input shall be included to allow for voltage variation of incoming signal without causing noticeable variation in luminaire to luminaire output.

5. Drivers shall track evenly across multiple luminaires at all light levels and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.

6. Control Input:

a. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
   1) Must meet IEC 60929 Annex E for General White Lighting LED drivers.
   2) Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V.
   3) Must meet ESTA E1.3 for RGBW LED drivers.
b. Digital (DALI Low Voltage Controlled) Dimming Drivers
   1) Must meet IEC 62386.
c. Digital Multiplex 512 (DMX Low Voltage Controlled) Dimming Drivers
   1) Must meet DMX / RDM: USITT DMX512A and ANSI E1.20 (Explore & Address).
   2) Must be capable of signal interpolation and smoothing of color and intensity transitions.

D. Other:
   1. For other luminaires, provide sources as specified. If specification is not complete, request clarification before ordering equipment.

2.9 REFLECTORS

A. Reflectors:
   1. Provide reflectors and reflecting cones or baffles fabricated from aluminum/plastic reflector sheet no less than minimum thickness listed below for each application, Reflector shall be absolutely free of tooling marks including spinning lines, and free of marks or indentation caused by riveting or other assembly techniques. No rivets, springs, or other hardware shall be visible after installation.
      a. Cones: 0.0500in (1.27mm)
      b. Wall wash kicker panels in cones: 0.0400in (1.01mm)
      c. Reflectors (non-structural: 0.0235in (0.59mm)
      d. Louvers/Baffles: 0.0200in (0.50mm)
   2. Provide reflectors and baffles of first-quality polished, buffed and anodized finish, "Alzak" or approved equal, and with specular or semi-specular finish color to be clear, unless specified otherwise. Provide reflector and baffles which produce no apparent brightness nor a source image, nor shall any part of the source be visible from 50° above nadir to 90° above nadir (vertical). That is, the reflector shall have a maximum 50° cutoff angle and a minimum 40° shielding angle.
   3. Provide other aluminum reflectors where required and formed and finished as noted on drawings and elsewhere in the specifications. Provide only reflectors free from blemishes, scratches, or indentations which would distort their reflective function and finished by means of the "Alzak" process, or approved equal, unless otherwise noted. No rivets, springs, or other hardware shall be visible after installation.
   4. For luminaires employing multi-color sources or sources emitting more than one distinct frequency of color, provide reflectors, cones, or baffles with low iridescent coating on all surfaces seen from normal viewing angles.
   5. Anodized aluminum reflectors shall have the following characteristics:
      a. Specular:
         1) 2 mg/in2 (0.31 mg/cm2) minimum Weight of Coating (Anodizing process. Coating of aluminum oxide: Reference ASTM Test Method B-137)
         2) 86 minimum Total Hemispherical Reflectance and 70 minimum Specular Component (Reference ASTM Test Method E-903-82 (testing utilizing a TR1

or TR2 Total Reflectometer is also acceptable pending issuance of ASTM standard))

3) 90 minimum Visual Clarify and 0.03 minimum Diffuseness at 15˚ (c) (Reference ASTM Test Method E-430-78 (1983))

B. Painted Reflectors:

1. Reflectors shall be completely formed before application of primer and enamel color coat or coats.
2. When requested, submit a sufficient quantity of flat steel panels having the identical primer and color coat or coats applied in the same manner as proposed for the contract items.
3. Tests will be required only in case of dispute about reflector characteristics. Tests may be required at any time before or during Contractor's warranty period. Contractor will pay the cost of tests, if required. Reflectors which do not meet the criteria expressed here will be replaced at Contractor's expense, with reflectors meeting specified requirements.
4. Tests:
   a. Painted reflectors shall have an initial reflection factor not less than 86 percent in the visible range of 400-700 nanometers as per ASTM Method E-424-71 as determined by independent laboratory test of fading, tested in the following manner: One half of sample shall be covered and remaining half shall be exposed to a 150 watt sunlamp placed 1/2in (12.7mm) above reflective surface for 72 hours. Comparison of exposed and unexposed sides shall show no visible fading or deterioration in appearance or reflectance.
   b. The percentage of Specular Gloss shall be a minimum of 80 percent as determined by ASTM Method D-532-T, Procedure A.

2.10 LENSES / FACEPLATES / TRIM

A. Where plastic lens is indicated, provide lens of 100 percent virgin acrylic (polymethyl methacrylate), nominal 0.125in (3mm) thick, unless otherwise indicated. Lens is to be strain-free, uniform in appearance, and destaticized.

B. Where clear acrylic lens is indicated, provide lens with a minimum visible light transmittance of 92 percent, unless otherwise indicated.

C. Where prismatic acrylic lens is indicated, lens shall be composed of 3/16in (4.7mm) square non-convex prismatic cones of maximum 0.080in (2mm) depth and aligned 45° to the length and width of the lens panel, unless otherwise specified. Lens shall be a minimum of 7.5 oz. per square foot (2289g/m2). Lens shall have minimum 80 percent visible light transmittance.

D. Where diffuse acrylic lens is indicated, lens shall be diffuse frosted white, high transmission acrylic with a minimum 73 percent visible light transmittance unless otherwise indicated. Provide nominal 0.125in (3mm) thick lens unless otherwise specified.

E. Where acrylic “overlay” is indicated, lens shall be supported by other rigid luminaire members, such as louvers or shelves. Lens shall be white or clear, as specified, with a minimum 79 percent visible light transmission for white lenses, and a minimum 83 percent transmission for clear lenses. Provide 0.040in (1mm) thick lens unless otherwise indicated.

F. Make lenses, louvers, or other light diffusing elements contained in frames removable, but positively held within the frames so that hinging or other motion of the frame will not cause the diffusing element to drop out.

G. For recessed luminaires with trim that is removable or open for access to the interior of the luminaire, and serves as a ceiling trim, provide trim that is positively held to the luminaire body by adjustable means that permit the trim to be drawn up to the ceiling as tight as necessary to insure complete contact of faceplate with ceiling surrounding the luminaire.

2.11 RATED LOCATION LUMINAIRES

A. General:
1. Provide luminaires designed and manufactured specifically for "rated" (e.g., damp, wet, shower, hazardous) location service. Components, including nuts, bolts, rivets, springs, and similar parts shall be made of materials of effective corrosion resistance, or of materials which have been subjected to finishing treatment which will assure such resistance.
2. Provide anodized aluminum for aluminum parts of exterior luminaires that are not specified as requiring a painted finish.
3. All luminaires shall be constructed according to UL procedures, and listed by UL ETL or CSA-US for the appropriate category.

B. Damp Location:
1. In addition to the requirements of paragraph, above, damp location luminaires shall meet or exceed the following criteria:
   a. Provide metal parts of luminaires, which are specified as requiring painting, for use in indoor, outdoor or damp locations, which are painted with suitable weather and/or moisture resisting qualities.
   b. Provide luminaires for use outdoors, or in areas designated as damp locations, which are suitably and effectively gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses or globes.
   c. Luminaires shall be UL, ETL or CSA-US listed for damp locations.

C. Wet Location:
1. In addition to the requirements of Paragraphs above, wet location luminaires shall meet or exceed the following criteria:
   a. Any exposed luminaires shall be UL, ETL or CSA/US rated for wet locations.
   b. Provide luminaires for use outdoors, or in areas designated as wet locations, which are suitably and effectively gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses or globes.
   c. Provide wet location luminaires with a suitable IP rating for their planned environment, unless otherwise specified in Appendix – Luminaire Schedule.
      1) Recessed luminaires suitable for wet location shall have a minimum IP54 rating.
      2) Surface mounted luminaires exposed to direct rain, shall have a minimum IP65 rating.
      3) Luminaires intended to be cleaned by high pressure waterjet cleaning, shall have a minimum IP66 rating.
      4) Ground-mounted luminaires located in floodplains, shall have a minimum IP68 rating.

2.12 LUMINAIRE DESCRIPTIONS

A. General:
1. Provide luminaires which conform to the above standards and criteria, as indicated on the drawings, and as indicated below and in APPENDIX - Luminaire Schedule.
2. Verify mounting conditions and trim for all luminaire types.
3. Verify all voltages, and verify which luminaires require ducted or plenum air supply or return capability or are to be static.
4. Catalogue or series numbers, when shown herein, are intended to assist in establishing general type or category of luminaires. Provide a luminaire that meets the complete performance descriptions, as well as information provided by detail drawings. Standard catalogue cuts, when included, are for general assistance. Written luminaire descriptions are the primary basis for luminaire specification. The Luminaire Schedule in the Appendix supersedes any legend or schedule on the Electrical Drawings.
5. The terminology "Or Approved Equal" if and only if used on the Luminaire Schedule, means the following: Products fabricated by alternative manufacturers to those listed may be submitted under the terms of the substitution clauses outlined in this Section. The products must meet the specifications in every way. Any substitutions or alternatives may be accepted or rejected without a detailed explanation.
6. Provide timely and written notification of any discrepancies between drawing and specifications before submitting bids. If such discrepancies are not resolved prior to the end of the bid period, the more costly alternative will be considered as included in the bid price. See paragraph above regarding definition of Acceptable Manufacturers.
7. All finishes are to be factory applied, including colored flanges and trims.

B. Spare Parts / Extra Stock:
1. Provide spare parts and extra stock to the Owner upon completion of the work. Extra stock quantities shall be included in main order to prevent additional cost to the Owner. All boxes shall be clearly labeled regarding contents, relevant luminaire type, and description. All spare parts shall be turned over to the Owner's authorized representative, and a receipt in duplicate, signed by the site representative shall be delivered to the Owner's authorized representative.
2. The following spare parts shall be provided as a minimum unless otherwise directed by Owner. Additional spare parts shall be provided as required by mention elsewhere in this specification, other sections of these Specifications, or the Contract Drawings:
    a. Sources/Lamps: Ten (10) percent (but not less than six (6) of each type)
    b. Transformers/ Power Supplies/LED Drivers: Five (5) percent (but not less than one (1) of each type)
    c. Lenses, Baffles, Snoots, Barndoors: Ten (10) percent (but not less than one (1) of each type
    d. Special Glass, Acrylic, Metal, Diffusers or Shapes for Types “XX”: Two (2) of each

C. LUMINAIRE SCHEDULE: SEE SECTION 26 51 13 APPENDIX LUMINAIRE SCHEDULE AT THE END OF THIS SECTION.
1. Complete specifications for the components (sources, power supplies, LED drivers, reflectors, lenses, etc.) of luminaires described below are found above in Part 2. The Luminaire Schedule below supersedes any similar legend or schedule issued previously or

issued concurrently on the Drawings. Provide timely and written notification of any discrepancies before preparing any bids or proceeding with any work.

2. Descriptions for additional luminaire types, specified by the Electrical Engineer, may be located on the Electrical Drawings.

2.13 POLE/LUMINAIRE ASSEMBLIES

A. 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.

B. Manufacturer will supply assembly to withstand 100 mph winds with a 1.3 gust factor without permanent deflection.

C. Manufacturer shall be responsible for design of and structural integrity of pole and complete base (i.e., concrete dimensions, rebar requirements, grounding and conduit requirements, drainage and ground compaction requirements under the specific installation conditions for the project).

PART 3 - EXECUTION

3.1 GENERAL

A. Install luminaires complete with light sources, as indicated, and with equipment, materials, parts, attachments, devices, aligner and filler clips, hardware, hangers, cables, supports, channels, frames and brackets necessary to make a safe, complete, and fully operative installation.

B. Verify and provide luminaires that are appropriate for the ceiling and mounting conditions of the project.

C. Coordinate with other trades as appropriate to properly interface installation of luminaires with other work.

D. Reject and do not install blemished, damaged, or unsatisfactory luminaires. Replace imperfect or unsatisfactory luminaires, if installed, as directed.

E. Set luminaires, when installed, to be true, and free of light leaks, warps, dents, or other irregularities. No light leaks are permitted at the ceiling line or from any visible part or joint of the luminaires. Install luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires, and secure in accordance with manufacturers' directions and approved shop drawings. Install all adjacent and continuous luminaires straight and trued, aligned in both plan and elevation. Supply and install alignment rods or joint straps as required to achieve this effect.

F. Provide finish for exposed parts or trims as specified. If not indicated, provide a finish as directed.

G. Do not install reflector cones, aperture plates, lenses, diffusers, louvers, and decorative elements of luminaires until completion of wet work, plastering, painting and general clean-up in the area of the luminaires.

H. Mount luminaires at heights and locations indicated on the Contract Drawings, or as required by Architect. Mounting heights specified or indicated are to be to the bottom of each luminaire for suspended and ceiling-mounted luminaires, and to the center of each luminaire for wall-mounted luminaires, unless otherwise noted. Obtain approval of the exact mounting for luminaires on the job before installation is commenced and, where applicable, after coordinating with the type, style, and pattern of the surface being installed.

I. Conform to the requirements of NFPA 70, and all other relevant codes. Supports shall be suitable for local seismic zone.

J. In Mechanical Equipment Rooms, luminaires shall be hung from ceilings after piping and equipment therein has been installed. Exact locations for such luminaires shall be determined at the job site during the course of the Work, in coordination with the mechanical work.

K. Adequately protect the housing of recessed luminaires during installation by internal blocking or framing to prevent distortion of sides, or dislocation of threaded lugs, which, upon completion, shall be in perfect alignment and match the corresponding holes in frames or rims. Holding screws shall be inserted freely without forcing and shall remain easily removable for servicing.

L. Ground non-current-carrying parts of electrical equipment in accordance with UL and NEC provisions.

M. Upon completion of installation of luminaires, and after building circuits have been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at the site, then re-test to demonstrate compliance. Otherwise, remove and replace with new units, and proceed with re-testing. Coordinate all test times and requirements with the Architect.
   1. For normal and emergency building lighting, upon completion of the installation, conduct an operating test to show that the equipment operates in accordance with the requirements of this and other relevant sections.
   2. Test all wiring with an insulation testing instrument, both before and after connection of luminaires and equipment. The minimum resistance shall be 250,000 ohms.

N. Upon completion of the installation, the luminaires and lighting equipment shall be in first class operating order and free from defects in condition and finish. At time of final inspection, all luminaires and equipment shall be clean, fully lamped, and be complete with required lenses or diffusers, reflectors, side panels, louvers, or other components necessary for the function of the luminaires. Any reflectors, lenses, diffusers, side panels or other parts damaged prior to the final inspection shall be replaced prior to inspection.

O. At the time of substantial completion and prior to field tests, replace lamps (excluding LED lamps and light engines) in interior luminaires which have been operating more than six months, or as work lights, or which are observed to be noticeably dimmed after use and testing during the construction period.

P. Luminaires and sources that are part of the Work of this section shall not be used for work lights during construction, except in Mechanical Equipment rooms. Provide adequate portable or temporary lighting for construction.

Q. Vibration Isolation: Mount and support all luminaires in such a manner to isolate the luminaire from structure-borne vibration, including but not limited to vibration caused by fans, motors, moveable tracks, moveable partitions, portable carts, vehicles, etc.

3.2 ACCESSIBILITY

A. Install equipment such as junction and pull boxes, luminaire housings, transformers, power supplies, ballasts, switches and controls, and other apparatus that shall be reached from time to time for operation and maintenance, to be easily accessible and appropriate for mounting and ceiling conditions.

3.3 SUPPORTS

A. Luminaires shall be securely fastened as per manufacturer's instructions. Provide plaster frames or mounting frames for luminaires that require them. Such frames shall be appropriate for the ceiling construction in which they are installed.

B. Provide necessary hardware with luminaires, such as stems, plates, plaster frames, hangers and similar items, for safe support of the luminaire. Provide plaster frames made of non-ferrous metal, or of steel that has been suitably rustproofed after fabrication, as described above.

C. Provide supports for luminaires that are adequate to support the weight of the luminaires.

D. Provide hanging devices which, if visible from normal viewing angles, exactly match luminaire finishes specified, unless otherwise noted.

E. Where necessary to meet fire resistance requirements of Building Code authorities, provide enclosures housing recessed luminaires that are constructed to meet or exceed required fire resistance rating.

F. Provide attachment devices including brackets and cast metal shapes with the requisite rigidity and strength to maintain continuous alignment of installed luminaires. Attach luminaires to ceiling support members, and do not depend upon lathing, plaster or ceiling tile for alignment or support.

G. Provide luminaires mounted in suspended ceilings that are supported by saddle hangers or the bars attached to runners or between crossbars of ceiling systems. Provide mounting splines or other positive means of maintaining alignment and rigidity.

H. Provide supporting members that are surface passivated, and which are primed or paint-dipped to resist corrosion.

I. Provide fastening devices of a positive locking type, which do not require special tools to apply or remove them. Do not use tie wires in place of fastening devices.

J. Contractor is responsible for the necessary suspension system. Contractor shall ascertain the structural reliability of supports provided under other Sections of the specification.

K. Attach reflectors to housings by means of safety chains, which shall prevent reflectors from falling. No part of the chain may be visible after installation, when viewed from any angle up to 50 degrees from the vertical.

L. Provide pendant or surface mounted luminaires with required mounting devices and accessories, including hickeys, stud-extensions, ball aligners, canopies, and stems. Uniformly maintain the luminaire heights shown on the Contract Drawings or established in the field. The allowable tolerances in individual luminaire mounting shall not exceed 1/4 inch (7mm) and may not vary more than 1/2 inch (14mm) from the mounting height shown on the drawings. Install luminaires hung in continuous runs absolutely level, and in line with each other. Hanging devices shall comply with code requirements.

M. Provide an approved ceiling canopy for each stem, exactly matching specified finishes.

N. Place stems to be vertical and plumb.

O. Provide at least two rigid supports for individually mounted suspended linear luminaires. Where luminaires are ganged, provide supports at 8-0” (2438mm) intervals, unless otherwise indicated.

P. Recessed and semi-recessed luminaires:
1. Support rods or wires shall be provided with a minimum of four rods or wires per luminaire and located not more than 0’-6” (152mm) from each corner of each luminaire.
2. Do not support luminaires by ceiling acoustical panels.
3. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such luminaires independently or with at least 0’-2 ¾” (19mm) metal channels spanning and wired to the ceiling tees.
4. Provide rods or wires for luminaire support under this section of the specifications.

Q. Seismic Protection for Lighting Luminaires: Provide luminaires and support to meet all applicable local codes and standards.

3.4 AIMING AND ADJUSTMENT:

A. Provide labor and tools for final aiming, focusing and adjustment, under the Architect's and Lighting Consultant’s supervision, of all adjustable luminaires after regular working hours, and after dark in daylighted areas, whenever necessary, at no additional cost to the project. All luminaires shall be locked into place so that the aiming is not disturbed during future replacement of light source or power supply.

B. Request preliminary aiming diagrams during the shop drawing submittals. If aiming diagrams are provided, pre-aim those luminaires during installation or prior to final aiming.

C. If colored or diffusing filters are specified, supply up to four (4) theatrical gels for each luminaire type, in colors to be selected by the Architect after installation. Place alternate gels over the luminaires as requested. When the final colors are selected, order the filters from the

manufacturer, and install them. Note that the time between ordering and shipping may be approximately four weeks.

D. When extra lenses, louvers or shields are specified, change accessories until a final selection is made.

E. Note final aiming and locked positions and include that information in the O&M manual.

3.5 CLEANING

A. Immediately prior to occupancy, clean reflector cones, reflectors, aperture plates, lenses, louvers, sources and decorative elements. As per manufacturer's instructions, de-staticize lenses after cleaning, installing them to leave no finger or dirt marks.

B. Upon completion of the luminaire installation and at the time of final inspection, luminaires shall be clean, and free from marks, dust, spotting or other defects. Replace any broken or defective parts prior to final inspection. Replace or make good all defects revealed by final inspection.

C. Protect installed luminaires from damage during the remainder of construction period.

3.6 COMMISSIONING

A. For any luminaire, power supply, LED driver, ballast, or lighting control system, provide a complete and operational system which meets or exceeds the performance specified.

B. The Owner shall provide for or engage an independent commissioning agent to verify that all components and system as a whole meets design intent and to evaluate the Contractor’s work. This includes evaluation and verification of all adjustable features, such as aiming angles, time clock settings, sensitivity settings, high end trim, fine tuning, customized settings, etc. Provide labor and equipment after normal working hours to correct and adjust system, working with or without direct supervision of commissioning agent until reasonable satisfaction has been achieved.

C. Provide Spares, as described in Part 2 above.

D. Submit a maintenance manual and operational submittals, as called for in Part 1 above, and under the conditions of the relevant General Requirements. After submittal is reviewed, make changes and resubmit, if necessary. After review and approval, this manual will be kept on site for reference use by facility maintenance personnel.

E. Assemble and submit in either a bound 8.5in x 11in (216mm x 279mm) format or electronic format, as confirmed by Owner, an Operation and Maintenance Manual that includes the following:
   1. A chart clearly documenting the luminaire, source, power supply, LED driver and/or ballast actually installed for each luminaire type, with product designations sufficient for reordering new product and components to match those installed.

a. For Digital Addressable Fixtures: A chart clearly documenting luminaire type, Make/Model, location, digital address, control address, for client operation and for future maintenance.

2. A current list of lighting distributors, manufacturers and manufacturer's representatives, (for the purposes of replacement, reordering or trouble-shooting). This list shall be keyed to the list of luminaires, sources, power supplies, LED drivers and ballasts, so that the Owner has a name, address and phone number of at least two (2) contacts for each product or component.
3. Shop drawings, technical data sheets, product technical documents, installation instructions, cut sheets, operating instructions, calibration instructions, and troubleshooting guides in the installation, including but not limited to sources, power supplies, LED drivers, ballasts and lighting control devices.
4. Color-coded as-built drawings showing all source, power supply, LED drivers and ballast types, to facilitate replacement. O&M Walk-through: Transfer of the O&M document will include a thorough walk-through and demonstration of equipment by Contractor for facility personnel.

F. Owner Training: At the Owner's convenience, provide a minimum of four (4) hours, not to exceed eight (8) hours, of expertise and training concerning the installation, characteristics, operations and maintenance of the Work of this Section. Such training shall take place after the Owner has been provided the final approved maintenance and operational submittals mentioned above.

G. Video-tape the training session and provide two (2) copies on flash/thumb drives, or DVD. Alternative electronic formats may be provided if mutually agreed upon.

PART 4 - APPENDICES

4.1 GENERAL

A. The appendices listed below are integral parts of the specifications and contract documents. If either Appendix is missing or incomplete, provide timely and written notification. Do not submit a bid based on incomplete information.

4.2 APPENDIX – LUMINAIRE SCHEDULE

A. See Part 2 above for complete specifications for the components (sources, power supplies, LED drivers, ballasts, reflectors, lenses, etc.) of the luminaires described in the Schedule. The Luminaire Schedule below supersedes any similar legend or schedule issued previously or issued concurrently on the drawings. Provide timely and written notification of any discrepancies before preparing any bids or proceeding with any work.

4.3 APPENDIX – LIGHT FIXTURE CUTSHEETS

A. Contractor shall provide luminaires that meet the complete performance descriptions in Part 2 and the Appendix above, along with luminaire detail drawings and sketches. If there are any discrepancies between luminaire descriptions, catalogue numbers, sketches, or catalogue cuts that

are unresolved during the bid period, the more costly option will be considered as included in the bid prices. The information in standard catalogue extracts are for general information only, and the product provided must meet all criteria described in the Luminaire Schedule and in this specification section above.

4.4 APPENDIX – LIGHTING CONTROL INTENT DIAGRAM

A. Contractor shall provide the lighting control system to meet the complete performance descriptions in this Appendix. Provide Manufacturer's written confirmation that the performance of the control intent diagram has been met or provide sequence of operation for all spaces described in this Appendix during the submittal process. If there are any discrepancies between the performance of the submitted system and the specified system identify these differences and why the specified performance cannot be met.

END OF SECTION 024119

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SECTION 271323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Type OFNP optical fiber cable.
   2. Optical fiber cable connecting hardware, patch panels, and cross-connects.

1.2 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.3 ACTION SUBMITTALS

A. Product Data:

   1. For each type of product.

B. Shop Drawings:

   1. System Labeling Schedules:

      a. Electronic copy of labeling schedules, in software and format selected by Owner.
      b. Electronic copy of labeling schedules that are part of cabling and asset identification system of software.

   2. Cabling administration drawings and printouts.
   3. Wiring diagrams showing typical schematic arrangement, including the following:

      a. Telecommunications rooms plans and elevations.
      b. Telecommunications pathways.
      c. Telecommunications system access points.
      d. Telecommunications grounding system.
      e. Cross-connects.
      f. Patch panels.
      g. Patch cords.

   4. Cross-Connect and Patch-Panel Drawings: Detail mounting assemblies and show elevations and physical relationship between installed components.

C. Certificates:

   1. For each type of product.

D. Field Quality-Control Submittals:

1. Optical fiber cable testing plan.
2. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Source Quality-Control Submittals:

1. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For optical fiber cable, splices, and connectors.

PART 2 - PRODUCTS

2.1 TYPE OFNP OPTICAL FIBER CABLE

A. Description: This category covers jacketed optical fiber cable for use in vertical runs in plenums, ducts, or other spaces used for environmental air within buildings in accordance with Article 770 of NFPA 70 containing no electrically conductive materials.

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN QAYK; including UL 1651.
3. General Characteristics:

a. Performance: TIA-568.3.
b. Inside Plant Mechanical Properties: ICEA S-83-596.
c. Inside-Outside Plant Mechanical Properties: ICEA S-104-696.
d. Jacket:

1) Cable cordage jacket, fiber, unit, and group color in accordance with TIA-598.
2) Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inch.

C. Type OFNP, Designation OS2, Inside-Outside Plant, Single-Mode Optical Fiber Cable:
1. Additional Characteristics:

a. Construction: TIA-492CAAB; 9 µm core diameter, 125 µm cladding diameter, with low water peak.

b. Minimum Overfilled Modal Bandwidth-Length Product: 500 MHz-km at 850 nm wavelength; 500 MHz-km at 1300 nm wavelength.

2. Options:

a. Configuration:

1) 12-fiber, single loose tube, optical fiber cable.
2) 24-fiber, stranded loose tube, optical fiber cable.

b. Maximum Attenuation: 0.5 dB/km at 1310 nm wavelength; 0.5 dB/km at 1550 nm wavelength.
c. Jacket Color: Yellow.

2.2 OPTICAL FIBER CABLE HARDWARE

A. Performance Criteria:

1. Fiber Optic Connector Intermateability Standard (FOCIS) specifications of TIA-604 series.
2. TIA-568.3.

B. Cross-Connects and Patch Panels: 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, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36 inch lengths.

D. Connector Type: Type LC complying with TIA-604-10, connectors.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of single optical fiber cable.
2. Insertion loss not more than 0.35 dB.

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of single optical fiber cable.
2. Insertion loss not more than 0.35 dB.
3. Designed to snap-in to patch panel or faceplate.

2.3 SOURCE QUALITY CONTROL

A. Tests and Inspections:
1. Test and inspect pre-terminated optical fiber cable assemblies, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in

accordance with TIA-526-14 and TIA-568.3 before delivering to site. Affix label with name and date of manufacturer's certification of system compliance.

B. Nonconforming Work:

1. Cables that do not pass tests and inspections will be considered defective.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate backbone cabling with protectors and demarcation point provided by communications service provider.

3.2 SELECTION OF OPTICAL FIBER TYPE

A. Installed in Vertical Shaft or Floor-to-Floor Riser:

1. Nonconductive:

a. Type OFNP in listed plenum communications raceway.
b. Type OFNP in metallic conduit.

B. Installed in Plenum, Duct, or Other Space Handling Environmental Air:

1. Nonconductive:

a. Type OFNP in listed plenum communications raceway.
b. Type OFNP in metallic conduit.

C. Installed in Location Other Than Riser or Plenum:

1. Nonconductive: Type OFNP in metallic conduit.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Optical fiber backbone cabling system must provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters may not be used as part of backbone cabling.

C. Comply with BICSI N1, NECA NEIS 1, and NECA NEIS 301.

D. Backbone cabling system must comply with transmission standards in TIA-568.1.

E. Telecommunications Pathways and Spaces: Comply with TIA-569.

F. Wiring Methods:
1. In Raceway: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
   a. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

2. In Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

G. Optical Fiber Cabling Installation:

1. Comply with TIA-568.1 and TIA-568.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable may contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inch and not more than 6 inch from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps may not be used for heating.
9. In communications equipment room, provide 10 ft long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

H. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable may not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

I. Group connecting hardware for cables into separate logical fields.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.5 GROUNDING

A. Install grounding in accordance with BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607 and NECA/BICSI-607.

C. Locate grounding bus bar to minimize length of bonding conductors. Fasten to wall allowing at least 2 inch clearance behind grounding bus bar. Connect grounding bus bar with minimum 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to grounding bus bar, using not smaller than 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: Class 3.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification must comply with TIA-606 for Class 3 level of administration.

C. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for cable and asset management software.

D. Cable Schedule: Install 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 electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inch of each termination and tap, where it is accessible in cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 ft.
4. Label each unit and field within distribution racks and frames.
5. Identification 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 different color for jacks and plugs of each service.

G. Labels must be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for qualified electrical testing laboratory certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

    a. Test instruments must meet or exceed applicable requirements in TIA-568.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction in accordance with TIA-526-14, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links must be less than 2.0 dB. Attenuation test results must be less than those calculated in accordance with equation in TIA-568.1.

B. Nonconforming Work:

1. Cables will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective cables and retest.

C. Collect, assemble, and submit test and inspection reports.

1. Data for each measurement must be documented.
2. Data for field quality-control report submittals must be printed in summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from instrument to computer, saved as text files, and printed and submitted.

END OF SECTION 271323

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Category 6 twisted pair cable.
   2. Twisted pair cable hardware, including plugs and jacks.
   3. Cable management system.

1.2 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

   1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
   2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
   3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

   1. System Labeling Schedules:

      a. Electronic copy of labeling schedules, in software and format selected by Owner.
      b. Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

   2. Cabling administration Drawings and printouts.

3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

C. Twisted pair cable testing plan.

D. Field Quality-Control Submittals:

1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings, cabling administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.7 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated:

    a. Type CMP complying with UL 1685.

2. Communications, Non-Plenum Rated:

    a. Type CMR complying with UL 1666.
    b. Type CMP or Type CMR in listed plenum or riser communications raceway.
    c. Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

A. Description: Four-pair, balanced twisted pair cable, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250 MHz.

B. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

C. Conductors: 100-ohm, 23 AWG solid copper.

D. Shielding/Screening: Unshielded twisted pairs (UTP).

E. Cable Rating: Plenum.

F. Jacket: Thermoplastic, color per owner requirements.

2.4 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 6.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.

D. Connecting Blocks:
1. 110-style IDC for Category 6.
2. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

E. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
3. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

F. Patch Cords: Factory-made, four-pair cables in 48-inch lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.

G. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.

H. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or cover plate.
3. Standard: Comply with TIA-568-C.2.

I. Cover Plate:

1. Two, Four, or Six port, vertical single gang cover plates designed to mount to single gang wall boxes.
2. Plastic Cover Plate: High-impact plastic. Coordinate color with Section 260533.16 " Boxes and Covers for Electrical Systems."
3. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

J. Legend:

1. Machine printed, in the field, using adhesive-tape label.

PART 3 - EXECUTION

3.1 INSTALLATION OF TWISTED PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. Routing: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

D. General Requirements for Cabling:

1. Comply with TIA-568-C.1.

2. Comply with BICSI's Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.3 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B.

B. Equipment grounding conductors.

C. Cable and Wire Identification:

1. 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.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.

5. Identification 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.

D. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Testing Preparation:

B. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

D. Nonconforming Work:

1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
2. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. Collect, assemble, and submit test and inspection reports.

END OF SECTION 271513

SECTION 281600 - INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Fully addressable, microprocessor-controlled intrusion detection, monitoring and notification hybrid system with automatic reporting to a station via dialer.
   1. System shall support both hardwired and wireless detection devices.
   2. Control panel shall be UL-rated for burglary

B. Contractor shall provide a complete system installation, including but not limited to all electrical wiring, secondary power supply, operating software, and programming.

C. Intrusion detection system shall be installed in accordance with the requirements of the Manufacturer and New York State Uniform Building Code and shall comply with the recommendations of the Security Industry Association.

1.2 REFERENCES

A. Underwriters Laboratories (UL):
   1. UL 609 - Local Burglar Alarm Units and Systems.
   2. UL 1023 - Household Burglar-Alarm System Units.

B. Federal Communications Commission (FCC):
   1. CFR Title 47, Part 15 - Radio Frequency Devices.
   2. CFR Title 47, Part 68 - Connection of Terminal Equipment to the Telephone Network.

C. NFPA 70: National Electric Code.

1.3 DEFINITIONS

A. Protected Zone: A protected premises or an area within protected premises that is provided with means to prevent an unwanted event.

B. Standard Intruder: A person who weighs 100 lbs or more and whose height is 60 inches or more.

C. Standard-Intruder Movement: Any movement, such as walking, running crawling, rolling, or jumping, of a "standard intruder" in a "protected zone".

D. Central Monitoring Station: Off Sight/Remote monitoring

1.4 SUBMITTALS

A. General: Prepare and submit Product Data, Wiring Diagrams and Equipment List as a single package to allow for a coordinated review.

B. Qualification Data: For installation personnel to demonstrate compliance with Quality Assurance provisions.

C. Product Data: For each alarm system component indicated including conductors, cables conduit, secondary power supply and operating software.
   1. Include data on features, including optional features, performance and electrical characteristics, ratings, dimensions, and finishes.
   2. Provide manufacturer's certifications documenting compliance with reference standards along with test results from independent testing laboratories.
   3. Provide detection patterns and adjustment ranges for motion sensors.

D. Wiring Diagrams: For power, signal, and control wiring.

E. Equipment List: Include each piece of equipment by model number, manufacturer, serial number, locations, and date of original installation.

F. Operation and Maintenance Data: Manufacturer's installation instructions and operational manuals. Submit O&M data along with product data.
   1. Annotate to identify part/serial numbers of installed components and actual system configuration.
   2. Identify replacement battery information (size/type) for each battery-powered device.

G. Closeout Submittals:
   1. Test Reports: "Record of Completion Report" as required under the "Field Quality Control" article.
   2. Manufacturer's Warranty: Copy of manufacturer's standard form of warranty.
   3. Contractor's Guarantee: Submitted on Contractor's official letterhead and/or containing the Contractor's official corporate seal and conforming to the requirements established under the "Warranty" article. Guarantee's submitted by an entity other than the prime contractor will not be accepted.
   4. Maintenance Service Agreement: Standard form of agreement conforming to the requirements established under the "Maintenance Service" article.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Installers shall be certified as security alarm system installers by NYS Division of licensing as well as local jurisdiction
   1. Contractor shall be a factory-authorized and trained installer of the system and shall be factory-trained and certified to repair the system after system acceptance.

B. Single Source: Obtain Control Panel, keypad, receivers, and detection devices components from a single manufacturer or from manufacturers recommended or approved by the manufacturer of the control panel.

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.

1.6 SPARE PARTS

A. Provide the following extra parts at completion of the Work. Spare parts shall not be used to replace defective parts during the required one-year maintenance period. Spare parts shall be identical to those approved for installation.
   1. Motion Sensors: two (2) each.
   2. Door Contacts: two (2) pair each type.

1.7 WARRANTY

A. Contractor's Guarantee: Contractor shall guarantee the intrusion alarm system to be free from mechanical or electrical defects. Promptly repair or replace any defective components at no expense to the Owner. Contractor's guarantee shall be in addition to the manufacturer's warranty.
   1. Guarantee Period: One (1) year from date of Physical Completion.

B. Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace intrusion alarm system components, Control Panel, RF transmitter and DACT that fail in materials or workmanship within the specified warranty period.
   1. Warranty Period: Three (3) years from date of Physical Completion.

1.8 MAINTENANCE SERVICE

A. Provide on-site maintenance service for a period of one (1) year from date of physical completion of the Contract.
   1. Utilize a fully equipped service organization capable of guaranteeing response within four (4) hours of a service call, 24 hours a day, 7 days a week.
   2. Provide "normal service" at no additional cost to the Owner. Normal service shall be defined as performing minor repairs and/or adjustments during the hours of 8:30 A.M. and 5:30 P.M., Mondays through Fridays. Service calls initiated by

11:00 A.M. on a weekday shall result in same-day service and shall be included as "normal service."

PART 2 - PRODUCTS

2.1 SYSTEM OPERATIONAL REQUIREMENTS

A. All system components shall be continuously monitored for normal, alarm and trouble conditions.

B. Signal Initiation.
1. Alarm signal initiation shall be by one or more of the following devices:
   a. Hardwired Motion sensor
   b. Wireless motion sensor.
   c. Magnetic door contact.
   d. Hardwired low-temperature sensor.
   5. Glass break detector

2. Trouble signal initiation shall be by one or more of the following devices or actions:
   a. Open circuits, shorts, or grounds in designated circuits.
   b. Opening, tampering with, or removing any alarm-initiating device.
   c. Loss of service on any monitored telephone line.
   d. Loss of primary or secondary power at the control panel.
   e. Loss of primary or secondary power at RF receiver(s).
   f. Abnormal position of any switch at the control panel.

C. Signal Actions
1. Alarm signal initiation shall cause the following events to occur:
   a. Activate audible alarm device(s).
2. Trouble signal initiation shall generate an audible signal at the control panel.
3. Trouble notification signal shall be distinct from other audible alarm signaling devices.

D. Control Panel Requirements
1. UL-listed and capable of functioning fully addressable system (minimum of eight partitions).
2. Capable of performing the following functions:
   a. Monitor and display the status of all system components in real time.
   b. Arm and disarm security alarm devices.
   c. Control relays.
3. Field programmable to allow customized identification of each signal initiation component.
4. Control panel shall function as the main point for programming, monitoring, accessing, securing, and troubleshooting the alarm system.
   a. Comply with ANSI CP-01 - Control Panel Standard Feature for False Alarm Reduction.

E. System shall automatically reboot without error or loss of alarm status or alarm data after any system disruption.

2.2 CONTROL PANEL

A. Subject to compliance with requirements, provide products by one of the following:
1. Honeywell, DMP, Bosch or approved equal

B. General Requirements.
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include real-time clock for time annotation of events on the event recorder and printer.
2. Four to Eight partition with each partition capable of supporting up to 48 addressable hardwired zone, polling loops and wireless addressable zones.
   a. Provide supervision of two notification appliance output circuits, RF receivers and relay modules.
3. Containing a master partition used exclusively to assign keypads for the purpose of viewing the status of all partitions at the same time (master keypad).

C. Alphanumeric Display and System Controls: Designed for interface between human operator at control panel and addressable system components including annunciation and supervision. Display alarm, trouble and component status messages and the programming and control menu.
1. Annunciator and Display: Back-lit liquid-crystal (LCD) type with minimum 32-character display.
2. Keypad: Designed to permit entry and execution of programming, display and control commands.

D: Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entering or leaving control panel.
1. Comply with NFPA 731.

E. Alarm Signal Transmission: Automatically transmit alarm and trouble conditions to local station via DACT or wireless dialer.

F. Primary Power: 24 V dc obtained from 120 V ac service and a power-supply module. Initiating devices, signaling lines, audible alarms, radio frequency transmitter and digital alarm communicator transmitter shall be powered by the 24-V dc source.
1. Alarm current draw shall not exceed 70 percent of the power-supply module rating.

G. Secondary Power: 24 V dc obtained from batteries, automatic battery charger and automatic transfer switch.
   1. Batteries: Sealed, valve-regulated, recombinant lead acid or maintenance-free lead-calcium.

H. Instructions: Printed instruction card mounted behind a plastic or glass cover in a stainless steel or aluminum frame. List all possible alarm, trouble and component status messages and describe appropriate response. Briefly describe functional operation of system under normal, trouble, alarm conditions. Include space for listing local fire department and police telephone numbers.

2.3 DIGITAL ALARM COMMUNICATOR TRANSMITER (DACT)-WIRELESS DAILER

A. Digital alarm communicator transmitter shall comply with UL 632 and be listed and labeled by an (Nationally Recognized Testing Laboratories) NRTL:
   1. Provide connection to (2) telephone lines via R31 jack ahead of any other devices connected to these same telephone lines.
   2. If POTS are not available, a wireless dialer shall be used

B. Functional Performance:
   1. Upon receipt of an alarm or trouble signal from the Control Panel, unit shall automatically capture one of two telephone lines and dial out to the central monitoring station.

   3 If service on either telephone line is interrupted for longer than 45 seconds, transmitter shall initiate a trouble signal to the Control Panel and transmit a trouble alarm, indicating loss of a telephone line, to the local station over the remaining telephone line.
   4. If service is lost on both telephone lines, transmitter shall initiate a trouble signal at the Control Panel.
   5. Transmitter shall automatically report restoration of telephone service to the local station.

C. Local functions and display at the DACT shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   4. Manual test report function and manual transmission clear indication.
   5. Communications failure with the Control Panel.

D. Digital data transmission shall include the following:
   1. Type of initiating device.
   2. The "protected zone" of the initiating device.
   3. Name and street address of building.

E. Secondary Power: Integral rechargeable battery with automatic charger.

2.4 RADIO-FREQUENCY RECEIVERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Honeywell
   2. Inovonics
   3. Napco
   4. DMP
   5. Bosch or approved equal

B. Functional Performance: The receiver shall support 16 or more encrypted wires transmitters at one time.
   1. The receiver shall recognize alarm, status and keypad messages from wireless transmitter operating at 345MHz or higher.

C. Physical Characteristics:
   1. Receiver shall be white in color to match area of location.

2.5 HARDWIRED MOTION SENSORS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Honeywell or approved equal

B. Functional Performance:
   1. Wireless dual technology; for alarm to be generated from device both the microwave and PIR sections shall activate simultaneously.

C. Physical Characteristics:
   1. Detector shall be no more than 2 7/8’W x 5” H and 2.5/16” deep or smaller

2.6 WIRELESS MOTION SENSORS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Honeywell
   2. Visonic
   3. DMP
   4. Napco or approved equal

B. Functional Performance:
   1. Wireless dual technology; for alarm to be generated from device both the microwave and PIR sections shall activate simultaneously.

C. Physical Characteristics:
   1. Detector shall be no more than 2 7/8’W x 5” H and 2.5/16” deep or smaller

2.7 MAGNETIC DOOR CONTACTS

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

1. Honeywell
2. Inovonics
3. Visonic or approved equal

B. Functional Performance:
1. Wireless surface mounted switches shall be used on doors as directed.
2. Switches shall activate when disturbance in the magnetic field occurs

D. Physical Characteristics:
1. In doorway where the door jam is white or brown, contact shall be the same color.

2.8 LOW-TEMPERATURE SENSOR (HARDWIRED)

A. Subject to compliance with requirements, provide products by one of the following:
1. Honeywell
2. Sentrol
3. IntelliSense or approved equal

B. Functional Performance:
1. Unit shall generate an alarm when the temperature drops below the set point of 45 degrees Fahrenheit; this shall also trigger local station notification

2.9 SIREN/AUDIBLE ALARMS

A. Subject to compliance with requirements, provide products by one of the following:
1. Amseco
2. Wheelock
3. ELK or approved equal

B. Functional Performance:
1. Unit shall be a compact design for mounting outdoors surface mount with a blue color strobe, which shall activate on all alarms.

C. Physical Characteristics:
1. Siren shall consist of a single tone that delivers a whole sound output of 120db and a dual-action reed plunger for cover and rear protection.
2. The unit shall have a strong polycarbonate housing and sturdy aluminum back plate to prevent warping and cracking.
3. The unit shall come completely assembled and ready for installation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine pathway for routing electrical wiring and locations for mounting system components to verify compliance with installation requirements and recommended clearances for operation and maintenance. Promptly notify Owner's representative of any existing construction that interferes with the system's proper installation and await instructions.

3.2 WIRING

A. General: Install wiring in accordance with the following reference standards:
   1. NECA 1
   2. TIA 570-B.

B. Conductor Material: Copper. Solid for No. 10 AWG and smaller.

C. The use of NM cable is strictly prohibited.

D. Install conductors and cables in raceways or conduit unless otherwise noted. Wiring not in conduit shall be UL listed plenum-type cable.
   1. Conduit is not required within existing wall and floor/ceiling assemblies that are covered with plaster or gypsum board.

E. Use pulling means, including fish tape, cable, rope and basket-weave wire/cable grips that will not damage conductors, conduit or raceways.

F. Install conduit and raceways parallel and perpendicular to surfaces of exposed structural members, and plumb or level with walls, floors and ceilings. Follow contour of molded surfaces where possible.

G. Separate power-limited and non-power -limited conductors as recommended by manufacturer. Bundle, lace, and train conductors to terminal points with no excess in a neat and workmanlike manner. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections using approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

H. Grounding: Ground control panel and associated circuits in accordance with IEEE 1100. Install ground wire from main electrical service ground to control panel. Utilize the shortest and straightest path possible.
   1. Avoid ground loops by making ground connections to alarm system components only at the control panel.

I. Identification: Tag wiring and cables with EZ markers that are numbered to coordinate with terminal blocks.

3.3 EQUIPMENT INSTALLATION

A. Control Panel: Flush mount with top of cabinet not more than 72 inches above the finished floor.

B. Motion Sensors: Wall mounted at corners of rooms as indicated on drawings with top of device at 7'-6" above the finished floor unless recommended otherwise by the device manufacturer.

C. Magnetic Contacts: Recessed within existing door jambs.

D. Wireless Contacts: Heavy duty Velcro to doors

3.4 SYSTEM PROGRAMMING

A. Furnish and install software system to provide a complete and operational intrusion alarm system in accordance with the requirements of these specifications.

B. Provide customized software programming for all user adjustable settings, status messages and device identification.
   1. Review and verify customizable settings and features with Owner's representative in advance.

C. Provide customized recorded messages for transmission of alarm and trouble signals to local station.
   1. Alarm notification of motion, door contact and low temperature recorded message shall be different from those of the asset protection activations.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Chief of Security. Schedule field tests representative at least 3 business days in advance.

B. Component Tests and Inspections:
   1. System Cabling: Test for incomplete circuitry, shorts and ground faults. Repair any faulty connections and re-test.
   2. Signal Initiation Devices: Activate each device and verify that signal is transmitted to control panel and system performs as specified. If necessary, adjust detector sensitivity or detection pattern and re-test device to verify device performs as specified.
   3. Perform all other tests or inspections recommended by the manufacturer of any device or component of the alarm system and in accordance with best industry practice.

C. System Testing: Perform system test in accordance with NFPA 730, 731 and 732, Chapter 8 for hold-up/panic alarms.
   1. Follow test methods prescribed in Section 10.4.3 of NFPA 731.
   2. Prepare and submit "Record of Completion" documenting results of system testing in accordance with the sample form provided in NFPA 731.

D. Alarm system will be considered defective if it does not pass all parts of each test or inspection.

3.6 DEMONSTRATION

A. Train Owner's representative to adjust, operate and maintain intrusion alarm system.
   1. Allow a minimum of two separate four-hour training sessions.

B. Conduct training session on-site using personnel who are thoroughly knowledgeable and familiar with the design, installation and operation of this particular system. Personnel engaged solely in sales or marketing are not acceptable.

C. Provide instruction in each of the following areas:
   1. Basic system design and operation.
   2. Warranty and guarantee notification procedures.
   3. Maintenance service procedures.
   4. Routine operating procedures.
   5. Meanings of trouble and error messages.
   6. User-adjustable settings and controls.
   7. Preventive maintenance requirements and procedures (including battery replacement).

D. Schedule training session with Owner's representative at least 5 business days in advance.
   1. Schedule initial training session after successfully completing final system testing.
   2. Schedule second training session approximately 12 months from date of Physical Completion.

E. Provide two (2) complete copies of all operational and maintenance data at least two weeks in advance of the initial training session.

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SECTION 282319 – IP-CCTV

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

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 AND SCOPE OF WORK

A. This section includes all labor and materials required for installing several IP cameras and a new GeoVision CCTV system server, that will be able incorporated all the existing cameras and network switches.

B. The New York State Division of Historic Preservation intends to install additional indoor box fixed, bullet and outdoor Dome PTZ cameras

C. Installation of the system shall include installation of the following:

1. All cameras shall be mounted per manufacturer recommendation.
2. CAT-6 UTP cable, in a color different from the current network cabling, run from camera to the Ethernet network switch (es). The contractor will be responsible for providing patch panel, switches, and patch cables.
3. Provide PoE either through the switch (es) or by high power mid-span Power over Ethernet (PoE) power injectors.
4. Provide all configuration, software installation and setup
5. Auxiliary equipment and materials as required to provide a complete and functioning IP- CCTV system.
6. Provide conduit and cable J-hooks as required for pathway from the cameras via network switches to the frontend computer/workstation.
7. Provide all labor, products and services required for the installation, programming, checkout, and testing of the CCTV system.
8. Provide system documentation and submittals.
9. Provide warranty and maintenance support.
10. Comply with codes, ordinances, regulations, and other legal requirements of NYS authorities which bear on installation and performance of work.
11. The work described in this section includes all labor, materials, equipment and services necessary to install and test the complete system. Any material not specifically mentioned in this section, or not shown on the contract drawings, but required for proper performance and operation of the specified system, shall be provided by the contractor.
12. Provide all products and perform all installation, programming, testing, and debugging of the system required for a fully integrated, functional and operating IP-CCTV system.

1.3 RELATED SECTIONS:

A. Division 16 - Electrical: Other sections of Division 16 as they apply to installation of an IP-CCTV system.

1.4 REFERENCES

A. General: The latest version of the following codes and standards shall be applicable.

B. Code of Federal Regulations (CFR)

C. 1. 47 CFR 76: Multichannel Video and Cable Television Service

D. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE C2: National Electrical Safety Code

2. IEEE 142: IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

3. IEEE C62.41-1991: Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

E. National Fire Protection Association (NFPA)

1. NFPA 70: National Electrical Code (NEC)

F. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA)

1. EIA-170: Electrical Performance Standards - Monochrome Television Studio Facilities

2. EIA-310-D: Cabinets, Racks, Panels, and Associated Equipment

3. TIA/EIA-250-C: Electrical Performance for Television Transmission Systems

4. TIA/EIA-568-B: Commercial Building Telecommunications Cabling Standard

G. Underwriters Laboratories Inc. (UL)

1. UL 2044: Commercial Closed-Circuit Television Equipment

1.5 CONFLICTS

A. Where conflicts exist between referenced requirements, comply with the one establishing the more stringent requirements.

B. Where conflicts exist between drawings and specifications, comply with the one establishing the more stringent requirements.

C. Where conflicts exist in equipment quantities, the contractor shall provide the greater amount.

1.6 SUBMITTALS

A. Product Data Submittals:

1. Submit catalog cut sheets, technical data sheets, manufacturer specifications and/or diagrams necessary to illustrate a product, material or system for some portion of the work. Product data literature is required on all items of material and equipment and should be clearly marked; identifying specific items proposed with a reference to the specifications requirement the item is being submitted for.
2. Product data shall include adequate descriptive literature and catalog cut sheets required for the engineer to ascertain that the proposed equipment and materials comply with specifications requirements.

B. Shop Drawings:

1. System block diagrams
2. System riser diagrams
3. Point-to-point wiring diagrams
4. Floor plans detailing device locations and cables, conduit routing
6. Prepare shop drawings using the latest release of AutoCAD

C. Prior to assembling or installing the work, prepare and submit shop drawings and product data literature for review and approval.

D. Review of product data shall not relieve the contractor from responsibility for deviations from the drawings or specifications, unless the contractor has, in writing, called attention to such deviations at the time of submission and secured written approval.

E. The contractor shall develop and submit complete submittals and do so in a timely manner. By failing to do so, the contractor agrees to be fully responsible for any and all damages, which might be incurred by the contractor failure to do so.

F. Submittals shall include three copies of product data submittals and three sets of shop drawings.

G. Product data submittals shall be submitted seven days from the date of notice to proceed, and shop drawings fourteen days from the date of notice to proceed.

H. Samples may be requested which shall be physical examples that represent materials, equipment, or workmanship and establish standards by which the work will be judged.

1.7 RECORD DOCUMENTATION

A. Record documentation shall include:
   1. Complete set of record drawings
   2. Operation and maintenance (O&M) manuals including software installation and configuration instructions
   3. Complete test reports
   4. Warranty documents

B. Record Drawings
   1. Provide a copy of corrected, approved shop drawings for the project, updated to show as-built condition. Include the manufacturers' brochures in the as-built documentation.
   2. Plans shall indicate exact device locations, panel terminations, cable routes and wire numbers as tagged on the cable tag.
   3. Final color-coded point-to-point wiring diagrams of each type of device shall included in the as-builts.
   4. Prepare as-builts using the latest release of AutoCAD. Submit three full-size sets of drawings, and the AutoCAD drawing files on CD-ROM to the NYS/Chief of Museum Security.

C. Operation and Maintenance Manuals
   1. Complete set of product data for all component parts
   2. Maintenance manuals for all component parts and the system as a whole
   3. Where applicable, operations manuals for component parts
   4. Copies of all material warranties
   5. Submit three identical sets of O&M manuals and one set in Adobe Acrobat file format on a thumb drive to the Chief of Museum Security.

D. Test Reports
   1. The contractor shall be responsible for recording all test data. Copies of all test results are to be submitted to the Chief of Museum Security for review as part of final acceptance and subsequently submitted to Chief of Museum Security for its records.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualification: The system manufacturer shall have been in business manufacturing similar products for at least five years.

B. Bidder Qualification: Equipment shall be installed by qualified individuals having at least five years experience installing and maintaining similar equipment. The qualified individuals shall have installed at least one system of similar type and size within the past five years. Submit evidence of successful installation, owner training and maintenance for a minimum of the previous five years. Provide listing of projects with verifiable references with names and telephone numbers. Provisions of this paragraph will be verified prior to issuance of a letter of award.

C. The contractor shall be a factory-authorized and trained dealer of the system and shall be factory-trained and certified to maintain/repair the system after system acceptance. The contractor shall maintain a fully staffed office within four hours travel time from the job site.

D. Personnel:

1. Personnel shall be qualified to accomplish all work promptly and satisfactorily.
2. Personnel shall have attended manufacturer training schools for equipment being serviced. Provide certificates of completion or other documentation showing manufacturer certification prior to award of contract.

1.9 TRAINING

A. Conduct an onsite system overview for the site staff (separate from the system testing) of the CCTV system to instruct the users on the scope and operations of the system.

B. Provide the following training upon completion of final testing and acceptance of the system:

1. Demonstrate operation of system during system overview tour. Demonstrate the system in all modes of operation.
2. Provide minimum of 4 hours of system maintenance training to designated personnel. Maintenance training shall cover all operations and technical training required for maintenance, preventative maintenance and system additions, moves and changes including detailed instructions on system software installation and modifications.
3. Provide minimum of 4 hours of operator training to system operators.

1.10 WARRANTY

A. The contractor shall warrant all labor, workmanship, and materials provided under this contract for a period of one year from date of certification of completion.

B. Warranty shall commence in accordance with the certification of substantial completion date and shall not be a function of material delivery dates.

C. If items supplied as part of this project have longer warranties, the contractor shall supply longer warranty.

D. If individual specifications sections require longer warranty, the contractor shall supply longer warranty.

E. Should a failure occur within the warranty period, the contractor shall provide all labor and materials necessary to restore the system at no cost to the New York State.

PART 2 - PRODUCTS

2.1 GENERAL

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. If items are damaged, do not install, but take immediate steps to obtain replacement.

2.2 CABLE, WIRE AND CONNECTORS

A. General: Provide all wire and cable. Wire and cable components shall be able to withstand the environment in which the wire or cable is installed for a minimum of 20 years.

B. CCTV Camera Signal Wiring: Category 6 UTP cable of a different color than the current network cabling. Cable shall be terminated at network switches or router using new patch panel via factory CAT-6 patch cables.

2.3 POWER DISTRIBUTION UNIT

A. Provide rack-mountable power strip for equipment rack. Power strip shall have multiple 20-amp outlets, a power indicator light, a reset fuse, and an internal CD ammeter, and shall be vertically mounted on rack stand.

2.4 NETWORK VIDEO SERVER (NVS)

A. The contractor shall configure and install the CCTV server, disk and backup devices. The contractor shall provide specifications for the server, disk and backup devices. The server shall be configured to archive 30 days of recorded video.

B. The server shall be a standalone with the ability to connect to the site's network in the future.

1. Support various network architectures including Ethernet 100BT and 1 Gigabit Ethernet
2. Support various types of network protocols including TCP/IP, IPX/SPX, and UDP
3. Allow remote access of the DVMS from anywhere on the end-users LAN or WAN
4. Playback stored video over the LAN or WAN for remote access of video clips.
5. The video server storage medium shall be a digital hard drive.
6. All video information can be stored on the server internal hard drive for immediate playback.
7. The hard drive shall work in a FIFO (First In First Out) mode to allow new video clips to overwrite old clips. The server shall be able to be configured to only store video for a user-definable number of days. Any recorded video older than the user-defined number of days shall not be available for either play back or viewing.
8. The system shall support the use of local RAID storage subsystems, which connect directly to the NVR via RAID Controller Card. The system shall support different RAID configurations including RAID 1, RAID 5 and RAID 10.
9. The system shall support the use of (IDE/ATA Drives) unit, (iSCSI/SATA Drives), (Fibre or SATA Drive), DELL iSCSI SAN and DELL DAS (SAS or SATA) storage solutions. In all cases, initial system configuration shall take place via the respective third-party software. However, system function thereafter shall be seamless to the user.

2.5 ETHERNET SWITCH & INERNET

A. The contractor shall provide all Ethernet switches or routers. Switches shall configure for Layer 2 TCP/IP communications.

2.6 VIDEO CAMERAS

A. General: Subject to compliance with the following requirements: Only Geovision Cameras meeting the below requirements will be acceptable. The camera shall:
   1. Provide video streams in HDTV 1080p (1920x1080) resolution at 30 frames per second using H.265 or Motion JPEG and provide streams up to 2560x1920 pixels resolution at 12 frames per second using H.265 or Motion JPEG or both.
   2. Equipped with day/night functionality and remote back focus capabilities
   3. Operate on an open source; Linux-based platform, and including a built-in web server
   4. Equipped with a slot for SD/SDHC memory card expansion
   5 Be manufactured with an all-metal body, supporting operations between -30C to +50C (-22F to +122F) and be IP66-rated

B. Hardware - the camera shall:
   1. Use a high-quality IR-sensitive progressive scan megapixel sensor
   2. Equipped with a removable IR-cut filter, providing so-called day/night functionality
   3. Equipped with a high quality varifocal lens with automated iris functionality
   4. Equipped with remote back focus functionality
   5. Provide pictures down to 0.5 lux while in day mode (with IR-filter in use) and down to 0.08 lux while in night mode (with IR-filter removed)
   6. Support memory expansion by providing an available SD/SDHC card slot

C. Video – The camera shall support/meet the following features/requirements:
   1. The camera shall be able to deliver at least two individually configurable full frame rate video streams of resolutions up to HDTV 720p over IP networks.
      a. Supported video resolutions shall include:
         1) 320x240
         2) 640x480
         3) 800x600
         4) 1024x768
         5) 1280x720 (HDTV 720p)
         6) 1600x1200
         7) 1920x1080 (HDTV 1080p)
         8) 2048x1536 161
         9) 2560x1920

D. Encoding – The camera shall:

1 Support Motion JPEG encoding in a selectable range from 1 up to 12 frames per second in all resolutions up to 2560x1920 pixels

2 Support Motion JPEG encoding in a selectable range from 1 up to 30 frames per second in all resolutions up to HDTV 1080p

3 Support H.265 encoding in a selectable range from 1 up to 12 frames per second in all resolutions up to 2560x1920 pixels

4 Support H.265 encoding in a selectable range from 1 up to 30 frames per second in all resolutions up to HDTV 1080p

5 Be able to provide independently configured simultaneous H.265 and Motion MPEG-4 streams

6 Support both Constant Bit Rate (CBR) and Variable Bit Rate (VBR) in H.265

7 Provide configurable compression levels

8 Support standard baseline profile H.265 with motion estimation

9 Transmission – The camera shall allow for video to be transported over:
a. HTTP (Unicast)
b. HTTPS (Unicast)
c. RTP (Unicast & Multicast)
d. RTP over RTSP (Unicast)
e. RTP over RTSP over HTTP (Unicast)
f. The camera shall support Quality of Service (QoS) to be able to prioritize traffic.

E. Image control - The camera shall:

1 Incorporate automatic and manual white balance

2 Be equipped with an electronic shutter and support automatic and manually-defined exposure zones operating in the range 1/6 and 1/25.500 second

3 Be equipped with wide dynamic range functionality

4 Provide back light compensation.

5 Allow for rotation of the image in steps of 90º

F Audio - The camera shall support two-way full duplex audio:

1 Input sources
a. External microphone
b. External line device

2 Output sources
a. External line device

3 Encoding - The camera shall support:
a. AAC LC at 8/16 kHz
b. G.711 PCM at 8 kHz
c. G.726 ADPCM at 8 kHz

G. Functionality

1 Web server
a. The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software. Configuration will require HTTPS for security. The web server shall meet the NYS IT security requirements.
b. Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.

2 The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.

3 The camera shall allow for automatic detection of the camera-based on UPnP and Bonjour when using a PC with an operating system supporting this feature.

4 The camera shall provide support for both IPv4 and IPv6.

5 The camera shall be equipped with an integrated event functionality, which can be trigged by:
a. External input
b. Video motion detection
c. Audio detection
d. Schedule
e. Camera tampering
f. Local storage full

6 Response to triggers shall include:
a. Notification, using TCP, SMTP or HTTP
b. Image upload, using FTP, SMTP or HTTP
c. Activating external output
Recording to local storage

7 The camera shall provide a memory buffer for pre & post alarm images.

H The camera shall incorporate support for at least IP, HTTP, HTTPS, SSL/TLS, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, NTP and Bonjour.

1. The SMTP implementation shall include support for SMTP authentication.

I Text overlay 3.01 The Camera shall:

1. Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.
2. To ensure accuracy, the camera shall accept external time synchronization from an NTP (Network Time Protocol) server.
3. Provide the ability to apply a privacy mask to the image.
4. Allow for the overlay of a graphical image, such as a logotype, into the image.

J Multi-view streaming

1 The camera shall allow for at least 8 individual and selectable areas of the image to be cropped out and made available as individual video streams.

K. Security - the camera shall:

1 Support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.

2 Support IEEE 802.1X authentication.

3 Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.

4 Restrict access to the built-in web server by usernames and passwords at three different levels.

L. API support

1 The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.

2 The camera shall conform to the network video standard as defined by the ONVIF organization.

M. Embedded application

1 The camera shall provide a platform allowing the upload of third- party applications into the camera.

2 The camera vendor shall provide a compatibility tool for the application vendor to verify the stability and performance impact of their uploaded application.

N Installation and maintenance

1 The camera shall:

2. Be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the Cameras configuration.
3. Support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.
4. Allow updates of the software (firmware) over the network, using FTP or HTTP.
5. Provide the ability to perform back focus adjustment remotely from the products web interface.
6. Provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.
7 All customer-specific settings shall be stored in a non-volatile memory and shall not be lost during power cuts or soft reset.

O. User logs - The camera shall:
1 Provide a log file, containing information about the 250 latest connections and access attempts since the unit‘s latest restart. The file shall include information about the connecting IP addresses and the time of connecting.
2 Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.

P Camera diagnostics – The camera shall:
1 Be equipped with an LED, indicating the camera functional status.

2 Be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.

Q Interfaces
1 The camera shall be equipped with one 100BASE-TX Fast Ethernet-port, using a standard RJ-45 socket and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all equipment in strict accordance with the manufacturer‘s recommendations and in compliance with the latest issue of industry standards, publications and regulations.
B. The installation shall be in compliance with the requirements of the NEC and OSHA and the rules, regulations and requirements of the FCC.
C. The installation shall comply with federal, city, county and state laws, ordinances, regulations, and codes applicable to the installation.
D. Grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.
E. Maintain consistent color-coding for all wiring/cabling in accordance with the approved shop drawings.
F. Provide for system growth of at least 100 percent. This capacity shall include all hardware, software, router and interfaces to the switchers.
G. All equipment connected to alternating current circuits shall be protected from power line surges.
H. All wire inputs and outputs shall be protected against surges induced on communication and device wiring.
I. All connections of stranded wire to screw terminals shall be by insulated spade lugs, crimp fastened to wire or as specified otherwise.
J. No splices shall be made within a conduit run.
K. Contractor shall not begin work on site or submit shop drawings, product data, design data, or other technical submittals until after making a detailed inspection of the existing site.
    1. Contractor shall verify:
        a. Information presented in the Contract Drawings is correct.
        b. Installation of equipment and work can be accomplished as indicated in the Contract Documents.
        c. Contractor‘s proposed equipment and methods of installation are compatible with existing conditions.

    2. Take field measurements and record other data required for preparation of shop drawings and other submittals.
    3. Contract Drawings and other documents indicate basic location, arrangement and routing of equipment and components.

    4. Within 7 days following Notice to Proceed, submit a report to the Chief of Museum Security describing the site investigation.
        a. Indicate noted conflicts between Contract Documents and site investigation information.
        b. Describe proposed modifications and reasons for change.
        c. Include Specifications sheets and written functional requirements to support findings.
        d. Prepare drawings and other data required showing variations and conditions requiring changes.

3.2 CCTV SYSTEM RACEWAYS

A. All conduits and raceways necessary to provide complete raceways for the CCTV system shall be provided by the Contractor unless otherwise noted.

B. The Contractor shall furnish and install conduits and raceways. Ensure that adequate conduit facilities are installed to support the intended systems.

C. The Contractor shall provide auxiliary raceways and junction boxes as required for interconnecting equipment.

D. All CCTV raceways shall be installed per the latest issue of the TIA/EIA-569A Standards and shall comply with the NEC and all other applicable state and local codes and regulations.

E. All CCTV raceways shall be grounded per NEC requirements.

F. The minimum size of conduits used for raceways shall be no less than ½ trade size. No section of conduit shall be longer than 100 feet between pull points and shall contain no more than 180 degrees of total bend.

G. Pull boxes should be placed in straight sections of conduit and not used in lieu of a bend. Pull boxes shall have a length of at least eight (8) times the trade-size diameter of the largest conduit.

H. Label all conduits at regular intervals and at each side of junction or pull boxes.

3.3 IDENTIFICATION

A. The Contractor shall label security equipment including cable, enclosures, cabinet, and monitors to uniquely identify all major system components.

B. Cable labels shall provide a unique identification scheme that shall ease cable tracing. Coordinate with the Division to determine any required labeling schemes prior to administering cable management techniques.

C. Labels shall be permanent, waterproof, and readable from one foot with permanent lettering and shall not be removable by normal cable handling or normal operations.

3.4 PROGRAMMING:

A. Provide all software, software licenses and programming for a complete and fully operational CCTV system, including but not limited to, all system interfaces, and camera, monitor and control device programming.

a. Enter all data needed to make the system operational including camera preset positions.

END OF SECTION 282319

SECTION 310519.13 – GEOTEXTILES

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the installation of separation/stabilization fabric as shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

A. The latest edition of the following standards, as referenced herein, shall be applicable.
   1. American Society for Testing and Materials (ASTM).

1.3 SUBMITTALS

A. Product Data:
   1. Submit Manufacturer's material specifications, product literature and installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery:
   1. Deliver sufficient materials to the site to prevent interruption of the work.
   2. All materials shall be inspected by Contractor upon delivery. Contractor shall notify Engineer of any damage. Products received at the site torn, with holes, deteriorated, or otherwise damaged will not be approved and shall be returned and replaced at no expense to the Owner.

B. Storage:
   1. All material shall be stored in strict accordance with the manufacturer's recommendations and as approved by the Engineer.
   2. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements, if stored outdoors, elevate, and protect geotextile with waterproof cover.

C. Handling:
   1. All material shall be handled in strict accordance with the manufacturer's recommendations and as approved by the Engineer.

PART 2 – PRODUCTS

2.1 WOVEN GEOTEXTILE

A. Stabilization Fabric: To be used beneath roadways and walks.

B. Composed of polymeric yarn interlaced to form a planar structure with uniform weave pattern.

C. Calendared or finished so yarns will retain their relative position with respect to each other.

D. Polymeric Yarn: Long-chain synthetic polymers (polyester or polypropylene) with stabilizer or inhibitors added to make filament resistant to deterioration due to heat and ultraviolet light exposure.

E. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

F. Unseamed Sheet Width: Minimum 12 feet.

G. Physical Properties: Conform to requirements noted below:

PROPERTY	DESIGN VALUE	TEST METHOD
Tensile Strength	315 pounds	ASTM D4632
Elongation	12 percent	ASTM D4632
Trapezoidal Tear	113 pounds	ASTM D4533
CBR Puncture Strength	900 pounds	ASTM D6241
A.O.S.	40 (US Sieve)	ASTM D4751
Permittivity	.05 sec^{-1}	ASTM D4491

2.2 NONWOVEN GEOTEXTILE

A. Separation/Filtration Fabric: To be used in drainage ditches, haybale installation, culvert outfall installations, rip-rap outfall installations, and cover material separation

B. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

C. Geotextile Edges; selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

D. Unseamed Sheet Width: Minimum 12 feet.

E. Physical Properties: Conform to the requirements noted below:

PROPERTY	DESIGN VALUE	TEST METHOD
Tensile Strength	160 pounds	ASTM D4632
Elongation	50 percent	ASTM D4632

Trapezoidal Tear	60 pounds	ASTM D4533
CBR Puncture Strength	400 pounds	ASTM D6241
A.O.S.	70 (US Sieve)	ASTM D4751
Permittivity	1.4 sec^{-1}	ASTM D4491

PART 3 – EXECUTION

3.1 GENERAL

A. The Contractor shall be responsible for the installation, and seaming of geotextile fabric in accordance with the specifications and the manufacturer's recommendations, as approved by the Engineer.

3.2 SUBGRADE PREPARATION

A. Surfaces to be covered with geotextile fabric shall be smooth and free of rocks, sticks, roots, sharp objects, and all debris that may damage the fabric. The surface to be covered shall be firm and unyielding, with no sudden changes or breaks in grade. There shall be no standing water or excessive moisture on the surface when the fabric is placed.

B. The compacted subgrade shall be maintained in a smooth, uniform, and compacted condition during installation of the fabric.

3.3 GEOTEXTILE INSTALLATION

A. The fabric shall be cleaned of all debris or other materials that may negatively affect the fabric's performance.

B. Mechanical equipment shall not be permitted to operate directly on the fabric unless authorized to do so by the manufacturer and approved by the Engineer.

C. Geotextile Placement:

1. Fabric shall be placed as recommended by the manufacturer and approved by the Engineer on surfaces which have been prepared to conform with these Specifications and found acceptable for fabric installation.
2. The fabric shall be placed as smooth and wrinkle-free as possible.
3. When installing geotextile in trenches, swales, ditches, etc., overlap geotextile in the direction of flow.
4. All areas of fabric damaged during installation as determined by the Engineer shall be repaired or replaced by the Contractor as specified at no additional cost to the Owner. Should the fabric be damaged during any step of the installation, the damaged section shall be repaired by covering it with a piece of fabric which extends at least 24 inches in all directions beyond the damaged area. The fabric shall be secured by sewing or bonding as approved by the Engineer.

5. At time of installation, fabric will be rejected if it has defects, ribs, holes, flaws, deterioration, or damage incurred during manufacture, transportation, handling, or storage. Damaged materials shall be removed and replaced at no additional cost to the Owner.
6. Fabric shall be placed with long dimension down slope.
7. Fabric shall be protected at all times during construction from contamination by surface run-off and any fabric so contaminated shall be removed and replaced with uncontaminated fabric.

D. Seams and Overlaps of Geotextile:
1. All overlaps shall be a minimum of 18 inches (450 mm).

3.4 COVER MATERIALS OVER GEOTEXTILES

A. Granular materials shall be placed on geotextiles as shown on the Drawings. During backdumping and spreading, a minimum depth of 6 inches of granular material shall be maintained at all times between the fabric and wheels of trucks or spreading equipment. All equipment used in spreading or traveling on the cover layer for any reason shall exert low ground pressures and shall be approved by the manufacturer and Engineer. Dozer blades, etc., shall not make direct contact with the fabric; however, if tears occur in the fabric during the spreading operation, the granular material shall be cleared from the fabric and the damaged area repaired as previously described.

B. The granular material shall be spread in the direction of fabric overlap. Large fabric wrinkles which may develop during the spreading operations shall be folded and flattened in the direction of the spreading. Occasionally, large folds may reduce the fabric overlap width. Special care shall be given to maintain proper overlap and fabric continuity.

C. All equipment spreading cover material or traveling on the cover layer shall avoid making sharp turns, quick stops, or quick starts.

D. Fabric shall be covered as soon as possible after placement to minimize exposure to sunlight. Fabric shall not be exposed for more than 5 days.

3.5 DISPOSAL OF SCRAP MATERIALS

A. On completion of installation, the Contractor shall legally dispose of all trash and scrap material off-site or in a location approved by the Owner and Engineer, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner.

END OF SECTION 310519.13

SECTION 311000 – SITE CLEARING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Protecting existing trees, shrubs, groundcovers, plants, and grass to remain.
   2. Removing existing trees, shrubs, groundcovers, plants, and grass.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping, or sealing, and abandoning site utilities in place removing site utilities.

1.2 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots.

1.3 MATERIAL OWNERSHIP

A. Except for excess stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 SUBMITTALS

A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

B. Record drawings, according to Section "Project Record Documents," identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

C. Certification: Submit written certification by qualified arborist that trees indicated to remain have been protected during the course of construction in accordance with recognized standards and that where damage did occur, trees were promptly and properly treated. Indicate which damaged trees (if any) are incapable of retaining full growth potential and are recommended to be replaced.

1.5 QUALITY ASSURANCE

A. Stake limits of clearing, grubbing, and stripping, prior to commencing of work.

B. Arborist Qualifications: Engage a qualified arborist who has successfully completed tree protection and trimming, to perform the following work:
   1. Remove branches from trees that are to remain, if required.
   2. Recommend procedures to compensate for loss of roots and perform initial pruning of branches and stimulation of root growth where removed to accommodate new construction.
   3. Recommend procedures for excavation and grading work juxtaposed to established plants.
   4. Perform tree repair work for damage incurred by new construction.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction. Detour routes shall be identified by adequate signs in accordance with the MUTCD.

B. Protect areas outside limits of disturbance from encroachment by construction personnel or equipment, regardless of property Ownership. Access shall be by specific, written permission or easement only.

C. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
   1. Do not proceed with work on adjoining property until directed by Owner’s Representative.

D. Salvageable Improvements: Carefully remove items indicated to be salvaged and deliver to storage location defined on the plans or specified here in.

E. Utility Locator Service: Properly notify utility locator service for area where Project is located before site clearing in accordance with local protocol.

F. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

G. Contractor shall verify existing grades prior to performing work under this section. If existing grades are at variance with the drawings, notify the Owner and receive instructions prior to proceeding. No additional compensation will be considered resulting from grade variances once site clearing has commenced.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag, fence, and protect trees and vegetation to remain or to be relocated.

C. Remove branches from trees that are to remain, if required to clear new construction and only if specifically approved by Owner's Representative.
1. Where directed by Engineer, extend pruning operation to restore natural shape of entire tree.
2. Cut branches and roots, if required, with sharp pruning instruments; do not break or chop.

D. Protect existing site improvements to remain from damage during construction.
1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TREE PROTECTION

A. Erect and maintain temporary fencing around tree drip line before starting site clearing. Remove fence when construction is complete.
1. Do not store construction materials, debris, or excavated material within fenced area.
2. Do not permit vehicles, equipment, or foot traffic within fenced area.
3. Maintain fenced area free of weeds and trash.

B. Do not machine excavate within tree drip line.

C. Where excavation for new construction is required within tree drip line, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

D. Do not allow exposed roots to dry out before permanent backfill is placed; provide temporary earth cover or pack with peat moss and wrap with burlap. Water and maintain in moist condition and temporarily support and protect from damage until permanently relocated and covered with earth.
1. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.

2. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
3. Backfill with soil as soon as possible.
4. Where trenching for utilities is required within drip line, tunnel under or around roots by hand digging. Do not cut main lateral roots or tap roots; cut only smaller roots that interfere with installation of new work. Cut roots with sharp pruning instruments; do not break or chop.

E. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Engineer and acceptable to the Owner.
1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Engineer and acceptable.

3.3 UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
1. Arrange with utility companies to shut off indicated utilities.
2. Owner will arrange to shut off indicated utilities when requested by Contractor.

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

D. Excavate for and remove underground utilities indicated to be removed.

3.4 CLEARING AND GRUBBING

A. Completely remove obstructions, trees, shrubs, stumps, roots, grass, and other vegetation to permit installation of new construction.
1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Use only hand methods for grubbing within tree protection zone.
4. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations in accordance with Section "Earth Moving" unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm) and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Where trees are designated to remain, stop topsoil stripping and adequate distance from the trees to prevent damage to the main root system.

C. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

D. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Limit height of topsoil stockpiles to 72 inches (1800 mm).
   2. Do not stockpile topsoil within tree protection zones.
   3. Dispose of excess topsoil as specified for waste material disposal.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.7 DISPOSAL

A. Burning of debris onsite is not permitted.

B. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
   1. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

C. Dispose of all diseased Elmwood within 4 days after cutting by burning or by other methods approved by the Department of Environmental Conservation.

END OF SECTION 311000

SECTION 312000 – EARTH MOVING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the preparation of the site, protection, excavation, embankment, drainage, dewatering, for site grading, as shown on the Drawings, and as herein specified.

B. The Contractor shall accept the site in the condition in which it exists at the time of the award of the Contract.

C. The Engineer shall determine the suitability of materials that are to be used in the work and should any materials encountered be unsatisfactory for the purpose intended, they shall be removed from the site at the Contractor's expense.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable.
      a. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering."
      b. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."

B. The Contractor shall comply with the requirements for soil erosion and sedimentation control, and other requirements of governmental authorities having jurisdiction, including the State of New York.

C. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of soils and aggregate with the specifications in accordance with Section "Quality Requirements."

1.3 SUBMITTALS

A. Samples:
   1. The Contractor shall furnish earth materials to the testing laboratory for analysis and report, as directed by the Engineer, or as outlined in the specifications.

B. Test Results:
   1. The testing laboratory shall submit written reports of all tests, investigations, and recommendations to the Contractor and the Engineer.

1.4 PROJECT REQUIREMENTS

A. Notify the Engineer of any unexpected subsurface condition.

B. Protection of Existing Utilities:
   1. Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate support and protection during earthwork operations, comply with OSHA requirements.
   2. Coordinate interruption and/or termination of utilities with the utility companies and the Owner.
   3. Provide a minimum of 48 hours' notice to the Owner and receive written notice to proceed before interrupting any utility.
   4. Demolish and completely remove from the site any existing underground utilities designated to be removed as shown on the Drawings or as specified in Section "Site Clearing."
   5. Repair any damaged utilities as acceptable to the Engineer, at no additional cost to the Owner.

C. Protection of Persons and Property:
   1. Barricade open excavations occurring as part of this work, and post with warning lights.
   2. Operate warning lights as recommended by authorities having jurisdiction.
   3. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
   4. Perform excavation within drip-line of large trees to remain by hand and protect the root system from damage or dryout to the greatest extent possible. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1-inch diameter and larger with emulsified asphalt tree paint.

PART 2 – PRODUCTS

2.1 PRECONSTRUCTION MATERIAL QUALIFICATION TESTING

A. A 100-pound minimum representative sample shall be obtained from each potential borrow source. If different material gradations are known to exist in the pit, samples shall be obtained for each material. Each sample shall be mixed thoroughly and reduced to test specimen size, in accordance with AASHTO T87. The test shall be performed in the order shown. Failure to pass any test is grounds for disqualification and shall lead to cessation of the test program for that material.
   1. Particle Size Analysis:
      a. Method: ASTM D422.
      b. Number of Tests: One (1) per potential source.
      c. Acceptance Criteria: Gradation within specified limits.
   2. Maximum Density Determination:
      a. Method: ASTM D1557, Modified Proctor.
      b. Number of Tests: One (1) per potential source.

3. Re-establish gradation and maximum density of fill material if source is changed during construction.

2.2 MATERIALS

A. Select Granular Material: Sound, durable, sand, gravel, stone, or blends with these materials, free from organic, frozen, or other deleterious materials, conforming to the requirements of NYSDOT Section 304 and meeting the following gradation requirements (NYSDOT Type 4):

SIEVE	PERCENT PASSING
2"	100
1/4"	30 - 65
No. 40	5 - 40
No. 200	0 - 10

B. Selected Fill: Sound, durable, sand, gravel, stone, or blends of these materials, free from organic, frozen or other deleterious materials.

SIEVE	PERCENT PASSING
4"	100
No. 40	0 - 70
No. 200	0 - 10

1. Fines passing No. 200 shall be non-plastic.
2. Particle size analysis shall show no gap grading.

PART 3 – EXECUTION

3.1 PREPARATION

A. Establish required lines, levels, contours, and datum.

B. Maintain benchmarks and other elevation control points. Re-establish, if disturbed or destroyed, at no additional cost to the Owner.

C. Establish location and extent of utilities before commencement of grading operations.

3.2 EXCAVATION

A. Excavation shall consist, in general, of the excavation of whatever substance is encountered to the lines, grades, and sections shown on the Drawings including excavation as necessary for grading and other similar features.

B. All suitable materials removed in excavation shall be used in the construction of embankments, subgrade, shoulders, slopes, and at such other places as directed. The Engineer shall be the sole judge of what constitutes suitable material.

C. During construction, the grading operations shall be executed in such a manner that the excavation will be well drained at all times. All grading shall be finished on neat, regular lines conforming to the sections and contours shown on the Plans.

D. Removal of materials beyond the indicated subgrade elevations, without authorization by the Engineer, shall be classified as unauthorized excavation and shall be performed at no additional cost to the Owner.

E. Excavation shall be performed in proper sequence with all other associated operations.

F. Maintain the slopes of excavation in a safe condition until completion of the grading operation.

G. All excavation work shall be inspected and approved by the Engineer before proceeding with construction.

H. Any excess excavation shall be removed from the site to disposal areas at the Contractor's expense.

3.3 FILL

A. All site fill shall be “selected fill” unless otherwise shown on the Drawings or directed by the Engineer. “Select granular fill” shall be placed in lieu of selected fill where directed by the Engineer.

B. Before depositing fills, the surface of the ground shall be cleared of all refuse, brush, and large stones. Conform to Section "Site Clearing."

C. Prior to placing fill over undistributed material, scarify to a minimum depth of 6 inches.

D. Where fills are made on hillsides or slopes, the slope of the original ground upon which the fill is to be placed shall be plowed or scarified deeply or where the slope ratio of the original ground is steeper than 2 horizontal to 1 vertical, the bank shall be stepped or benched.

E. The original ground shall be proof rolled until the underlying soil is thoroughly compacted to the satisfaction of the Engineer before any filling is begun. A steel-wheel tandem roller weighing 8 to 10 tons or equipment capable of obtaining the same effort shall be used to obtain a thoroughly compacted subgrade. Remove or recompact any soft or loose soils as determined by the Engineer prior to filling.

F. A thoroughly and satisfactorily subgrade is defined as having a minimum dry density of 95 percent of the maximum density of the material used. The subgrade material shall be compacted at a moisture content suitable for obtaining the required density.

G. Place backfill and fill materials in layers not more than 12 inches in loose depth unless shown otherwise on the Drawings. Lift height shall be governed by the ability of the compaction equipment to obtain the required compaction with 12 inches as a maximum lift height. Before compaction, moisten or aerate each layer as necessary to facilitate compaction to the required density. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost, ice, ponded water, or extraneous debris.

H. When work is suspended during periods of freezing weather, measures shall be taken to prevent fill already in place from freezing. Upon resumption of work after any inclement weather, prepare the exposed surface by proof rolling to identify any zones of soft/loose soils. Soft/loose materials or frozen soils shall be removed and replaced by compacted granular fill.

I. Moisture Control:

1. Where fill or backfill must be moisture conditioned before compaction, uniformly apply water to the surface and to each layer of fill or backfill. Prevent ponding or other free water on surface subsequent to, or during, compaction operations.
2. Remove and replace, or scarify and air dry, soil that is too wet to permit compaction to specified density. Soil that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing, or pulverizing until moisture content is reduced to a value which will permit compaction to the percentage of maximum density specified.

J. All fill shall be thoroughly and satisfactorily compacted to 95 percent of the maximum density of material used.

3.4 GRADING

A. The present and finished grade lines are shown on the Drawings. Grade over the entire area, as shown on the drawings, shall be to the finished subgrade levels. Upon completion of this work, all debris shall be cleaned out and removed from the premises.

B. All cutting, filling, backfilling and grading necessary shall be done to bring the area to the following grade or subgrade levels:

1. For roadway surface areas to the finished subgrade levels specified on the contract drawings.
2. For areas to be topsoiled and seeded to within 6 inches of the finished grade.
3. For other surface treatments as detailed on the Drawings.

C. Sufficient grading must be done during the progress of the work so that the entire site shall be well drained and free from water pockets.

D. Finish grading, including dressing swales, cleaning up excess footing excavation, dressing terraces, disposing of excess material and all other work necessary to prepare the site for topsoil and seeding shall be done after construction of structures and roadway surface areas is substantially complete.

3.5 COMPACTION EQUIPMENT

A. Compaction equipment used for the Work is subject to approval by the Engineer. Any equipment not originally manufactured for compaction purposes and equipment which is not in proper working order will not be approved. Furnish manufacturer's specifications covering data not obvious from a visual inspection of the equipment and necessary to determine its classification and performance characteristics.

B. Vibratory Drum Compactors: A self-propelled compactor classified for use according to the developed compactive force rating (CFR) per linear inch of drum width (PLI). The actual operating frequency of the compactor will determine the PLI rating. Compute the CFR at the actual operating frequency for the compactor in accordance with the applicable portions of NYSDOT Section 203-3.03.2.b and the corresponding maximum lift thickness in accordance with Figure 203-2.

1. Furnish one vibratory reed tachometer for the exclusive use of the Engineer. Tachometers shall have a frequency range adequate to cover the operating frequencies of all vibratory compactors on the project with scale divisions of 50 vibrations per minute or less. The tachometer will be returned by the Owner's Representative at the closeout of the project.
2. Approval of vibratory compactors usage is contingent upon proper operation of equipment at all times during compaction operations.
3. Compaction equipment other than vibratory drum compactors may be used subject to the approval of the Owner's Representative. Submit specifications at least two (2) weeks prior to use of this equipment.
4. Do not use vibratory drum compactors after concrete is poured.

3.6 DRAINAGE AND DEWATERING

A. Prevent surface, subsurface or ground water from flowing into excavation and from flooding project area, as well as surrounding areas.

B. Do not allow water to accumulate in excavations. Remove water to prevent soil changes detrimental to the stability of subgrades.

C. Provide and maintain the pumps, well points, sumps, suction and discharge lines, and other dewatering components necessary to convey water away from excavations.

D. Provide and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations by dewatering, to collection or run-off areas.

E. Dewatering operations shall be as directed by the Engineer and performed in accordance with Section "Dewatering."

3.7 FIELD QUALITY CONTROL

A. Notify the Engineer at least one (1) working day in advance of all phases of filling and backfilling operations.

B. Compaction testing shall be performed to ascertain the compacted density of the fill and backfill materials in accordance with the following methods:

1. In-place relative density:
   a. Method: AASHTO T310, Nuclear Method.
   b. Number of Tests: One (1) per 8-inch vertical lift.

1) Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one (1) test for every 2,000 square feet or less of paved area of building slab, but in no case fewer than three (3) tests.

C. The Engineer may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions, at the Contractor's expense.

D. Acceptance Criteria: The sole criterion for acceptability of in-place fill shall be in situ dry density. Minimum dry density for all fill or backfill shall be 95 percent of the maximum dry density. If a test fails to qualify, the fill shall be further compacted and retested. Subsequent test failures shall be followed by removal and replacement of the material.

3.8 CLEAN UP

A. Provide and maintain protections or newly filled areas against damage. Upon completion or when directed, correct all damaged and deficient work by building up low spots and remove temporary protections, fencing, shoring, and bracing.

B. Remove all surplus excavated material not required for filling and backfilling and legally dispose of same away from premises.

C. Leave the premises and work in clean, satisfactory condition, ready to receive subsequent operations.

END OF SECTION 312000

SECTION 312319 – DEWATERING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes provisions for a dewatering system to continuously lower and control groundwater levels and hydrostatic pressures in order to maintain near-dry conditions for construction of the work as shown on the plans and specified herein.

1.2 SUBMITTALS

A. Submit the following:
   1. Description: of proposed dewatering system.
   2. Layout: of dewatering system, including location of sumps, deep wells, well points, header pipes, pumps, discharge lines, and observation wells.
   3. Details: of dewatering system, including installation methods for deep wells, well points and observation wells, depths of wells, material descriptions, pipe sizes, intake screen sizes, and pump capacities.
   4. Estimate: of time required to lower groundwater levels after start of pumping

1.3 JOB CONDITIONS

A. Site soil boring data and samples, soil laboratory testing, and any soil reports shall be made available to prospective bidders for study and review. Bidders must make their own interpretation of subsurface conditions that may affect methods or the cost of construction of the Work.

PART 2 – PRODUCTS

2.1 DEWATERING SYSTEM

A. Provide a dewatering system of adequate size and capacity to lower and maintain the groundwater at the specified level. The system shall include standby pumps and power source for continuous operation.
   1. Dewatering system shall consist of wellpoints, deep wells, cut-off walls, riser pipes, swing joints, header lines, valves, pumps, discharge lines, and all other necessary fittings, accessories, and equipment for a complete operating system. Provide hole punches, sand backfill, and clay plugs as required by soil conditions.

B. Observation Wellpoints: Provide groundwater reading wells or piezometers to monitor the groundwater level, as indicated on the approved Shop Drawings, or as directed by the Engineer.

C. Sand: Clean concrete sand conforming to ASTM C33.

PART 3 – EXECUTION

3.1 PREPARATION

A. Install the observation well points at locations indicated on approved Shop Drawings or where directed by the Engineer. Install observation wellpoints in accordance with manufacturer's printed instructions and in accordance with approved Shop Drawings. Provide sand backfill around wellpoint. Test each observation wellpoint to verify that the installation is performing properly.

B. Protect observation well standpipes from damage by construction operations and maintain accessibility to them. Maintain reading wells until groundwater is allowed to return to its normal level.

3.2 INSTALLATION

A. Install the dewatering system in accordance with approved Shop Drawings and as required by site conditions. Locate elements of the system to allow a continuous dewatering operation without interfering with the installation of any permanent project Work.

3.3 OPERATION

A. Keep the system in continuous operation from the time excavation is started in the dewatering area (or before if required by site conditions to lower the groundwater to the elevations specified) until the time backfilling is completed at least 2 feet above the normal groundwater level.
   1. Do not discontinue dewatering operations without specific approval from the Engineer.
   2. Rates of groundwater withdrawal during dewatering operations, shall at all times be below the rate at which soil particles are removed from the existing soils.

B. In the event excavation proceeds subsequent to dewatering as specified above, and the groundwater level is found to be within two feet of the excavation, the dewatering Contractor shall immediately continue to dewater as specified herein, including, but not limited to, additional dewatering and monitoring facilities, at no additional cost to the Owner. The excavation shall not be allowed to proceed below groundwater.

3.4 FIELD CONTROL

A. Maintain a careful check to detect any settlement in existing adjacent Work. Notify the Engineer of any signs of settlement. Establish settlement point bench marks and take periodic readings as directed. The Contractor shall take all such precautions and do any and all Work necessary to protect the stability and integrity of adjacent lands. Pavements, buildings, and utilities from settlement or other movement that may be caused by his dewatering operations. The Contractor shall be solely responsible for any damage or injury to adjacent lands, pavements, buildings, or utilities caused by his dewatering or other operations or his failure to use corrective or preventive procedures or methods.

B. Take and record measurements of the groundwater in each reading and pumping well periodically and when directed by the Engineer.

3.5 DISCHARGE

A. Dispose of all water removed from the excavation in such a manner as not to endanger public health, property, or any portion of the Work under construction or completed.

B. Dispose of water in such a manner as to cause no inconvenience to others on or adjacent to the site.

C. Convey water from the excavation in a closed conduit. Do not use trench excavations as temporary drainage ditches.

D. Disposal of water shall be approved by the Engineer and shall not cause erosion or sedimentation to occur in existing drainage systems. All sedimentation or blocking of existing systems shall be thoroughly cleaned and returned to original condition by the Contractor at his own expense.

E. Provide approved sediment traps when water is conveyed into water courses.

3.6 REMOVAL

A. When system is no longer required, gradually decrease the pumping rate until the water table resumes its natural position so that the velocity of the returning groundwater will be low enough as not to carry fines with it.

B. When the dewatering system is no longer required and when directed by the Engineer, dismantle and remove the system and all appurtenances from the site.

END OF SECTION 312319

SECTION 312333 – TRENCHING AND BACKFILLING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the excavation of trenching, backfilling, compacting, dewatering, excavation support and disposal, as shown on the Contract Drawings, and as herein specified.

B. The Engineer will determine the suitability of materials that are to be used in the work and should any materials encountered be unsatisfactory for the purpose intended, they shall be removed from the site at the Contractor's expense.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable.
      a. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering.".
      b. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."
      c. American Society for Testing and Materials (ASTM).
      d. National Electric Code (NEC).

B. The Contractor shall comply with the requirements for soil erosion and sedimentation control and other requirements of governmental authorities having jurisdiction, including the State.

C. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of soils and aggregate with the specifications in accordance with Section "Quality Requirements."

1.3 SUBMITTALS

A. Samples:
   1. The Contractor shall furnish representative earth materials to the testing laboratory for analysis and report, as directed by the Engineer, or as outlined in the specifications.

B. Test Results:
   1. The testing laboratory shall submit written reports of all tests, investigations, findings, and recommendations to the Contractor and the Engineer.

1.4 PROJECT REQUIREMENTS

A. Notify the Engineer of any unexpected subsurface condition.

B. Protect excavations by shoring, bracing, sheet piling, or by other methods, as required to ensure the stability of the excavation. Comply with OSHA requirements.

C. Underpin or otherwise support structures adjacent to the excavation, which may be damaged by the excavation. This includes service lines.

D. Protection of Existing Utilities:
   1. Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Comply with OSHA requirements.
   2. Coordinate interruption and/or termination of utilities with the utility companies and the Owner.
   3. Provide a minimum of 48 hours' notice to the Owner and receive written notice to proceed before interrupting any utility.

E. Demolish and completely remove from the site any existing underground utilities designated to be removed, as shown on the Drawings or as specified.

F. Repair any damaged utilities as acceptable to the Owner, Engineer, and utility company at no additional cost to the Owner.

G. Contractor shall comply with maintenance and protection requirements as approved by the authority having jurisdiction.

H. Protection of Persons and Property:
   1. Barricade open excavations occurring as part of this work and post with warning lights, if required.
   2. Operate warning lights as recommended by authorities having jurisdiction.
   3. Protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
   4. Perform excavation within drip-line of trees to remain by hand and protect the root system from damage or dryout to the greatest extent possible. Maintain moist conditions for root system and cover exposed roots with burlap. Paint cut roots of 1-inch diameter and larger with emulsified asphalt tree paint.

PART 2 – PRODUCTS

2.1 PRECONSTRUCTION MATERIAL QUALIFICATION TESTING

A. General:
   1. Sufficient size samples shall be obtained from the potential borrow source to allow completion of tests listed in paragraph B below. Samples may be obtained from test borings, test pits, or from borrow pit faces provided that surficial dry or wet soil is removed to expose undisturbed earth. Tests listed below shall be performed on each sample obtained. A minimum of 3 representative samples from each potential borrow source shall be furnished to the testing laboratory for prequalification testing. Test data shall be provided to the Engineer a minimum of 2 weeks prior to construction for

approval of borrow source. Three test reports completed within three months prior to construction may be submitted for commercial earth borrow sources or suppliers of stone products (crushed stone or graded stone products) in lieu of prequalification tests as approved by the Engineer.

B. Material Tests:

1. Particle Size Analysis:
   a. Method: ASTM D422.
   b. Number of Tests: One (1) per sample; three (3) per potential source.
   c. Acceptance Criteria: Gradation within specified limits.
2. Maximum Density Determination:
   a. Method: ASTM D1557 - Modified Proctor.
   b. Number of Tests: One (1) per sample; three (3) per potential source.
3. Re-establish gradation and maximum density of fill material if source is changed during construction.

2.2 MATERIALS

A. Pipe Zone Bedding: Select mixture of graded crushed stone, free from organic, frozen or other deleterious materials, conforming to the requirements of NYSDOT Section 703-02 and meeting the following gradation requirements (NYSDOT Size 2).

SIEVE	PERCENT PASSING
1-1/2"	100
1"	90 – 100
1/2"	0 – 15

B. Pipe Zone Backfill: Sound, durable sand, gravel, stone or blends of these materials, free from organic, frozen or other deleterious materials, conforming to the requirements of NYSDOT Section 304 and meeting the following gradation requirements (NYSDOT Subbase Type 4):

SIEVE	PERCENT PASSING
2"	100
1/4"	30 – 65
No. 40	5 – 40
No. 200	0 – 10

C. Suitable Material: Sound, durable sand, gravel, stone or blends of these materials, free from organic, frozen or other deleterious materials, conforming to the requirements of NYSDOT 203-2.02C and meeting the following gradation requirements:

SIEVE	PERCENT PASSING
4"	100
No. 40	0 – 70
No. 200	0 – 15

1. Run-of-trench material, meeting the above criteria, shall be considered suitable material and shall be used for trench backfill only after tested in accordance with Section "Quality Requirements" and approved by the Engineer. The Contractor shall pay for all additional testing required to determine the conformance of run-of-trench material, if at any time

during the Work this material appears to be in non-conformance in the opinion of the Engineer.

PART 3 – EXECUTION

3.1 PREPARATION

A. Establish required lines, levels, contours, and datum.

B. Maintain benchmarks and other elevation control points; re-establish if disturbed or destroyed at no additional cost to the Owner.

C. Establish location and extent of existing utilities prior to commencement of excavation.

3.2 EXCAVATION

A. All excavation shall be made to such depth as required and of the width shown on the Drawings to provide suitable room for building the structures and laying the pipe(s) they are to contain and for sheeting, shoring, pumping and draining as necessary, and for removing peat, silt, or any other materials which the Engineer may deem unsuitable. Hand trench excavation may be required to protect existing utilities and structures.

B. Trench excavation for pipes shall be made by open cut to accommodate the pipe or structure at the depths indicated on the Drawings. Excavation shall be made to such a depth and to the width indicated on the Drawings so as to allow a minimum of 8 inches of pipe zone bedding to be placed beneath the bottom of all structures and barrels, bells or couplings of all pipes installed unless otherwise specified on the Drawings.

C. The bottom of the trench shall be accurately graded to provide a uniform layer of bedding material as required for each section of pipe. Trim and shape trench bottoms and leave free of irregularities, lumps, and projections.

D. Stockpile excavated subsoil for reuse where directed or approved.

E. Over excavation/undercut: If, in the opinion of the Engineer, existing material below the trench grade is unsuitable for properly placing bedding material and laying pipe, the Contractor shall excavate and remove the unsuitable material and replace the same with an approved pipe zone bedding material properly compacted.

F. Stability of Excavation: Slope sides of excavations shall comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavation in safe condition until completion of backfilling.

G. Removal of materials beyond the indicated subgrade elevations, without authorization by the Engineer, shall be classified as unauthorized excavation and shall be performed at no additional cost to the Owner.

3.3 DEWATERING

A. The Contractor shall remove all water from the excavation promptly and continuously throughout the progress of the work and shall keep the excavation dry at all times until the work is completed and excavation is backfilled or have sufficient weight to resist uplift pressures. Groundwater levels shall be depressed to a minimum of 2 feet below excavation subgrade. No pipe or structure is to be laid in water and water shall not be allowed to rise on or flow over any pipe or structure until such time as approved by the Engineer.

B. Provide a suitable point of discharge from dewatering operations shall be conveyed in a non-erosive manner satisfactory to the Engineer.

C. Precautions shall be taken to protect uncompleted work from flooding during storms or from other causes. All pipe lines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected.

3.4 BEDDING AND BACKFILLING

A. All pipe trenches backfill (pipe zone bedding, pipe zone backfill and trench backfill) shall be compacted by tamping or rolling to achieve a minimum dry density of 90 percent of the modified Proctor maximum dry density of the material used (ASTM D1557). Backfill in pipe trenches to be covered with pavement shall be compacted to a minimum of 95 percent of modified Proctor maximum dry density. Backfill materials shall be placed with water content within plus or minus 4 percent of optimum moisture content per the modified Proctor method (ASTM D1557). Any water used for compaction shall be provided by the Contractor at his own expense. The Contractor is responsible for the repair of any trench settlement at no expense to the owner.

B. Bedding and backfilling shall be accomplished in three stages unless otherwise specified on the Contract Drawings. The first stage shall involve placement of "pipe zone bedding" as a layer(s) of selected material required to support, or to stabilize unsound or unsatisfactory foundation conditions. The second stage shall involve placement of "pipe zone backfill" from the top of the bedding material up to 1 foot above the pipe. The third stage involves the placement of "trench backfill" in the remainder of the trench up to the surface of the ground or the bottom of any special surface treatment subgrade elevation.

C. The bedding material shall be placed in the trench after the trench has been excavated a minimum of 8 inches below the bell of the pipe to permit the placing of not less than 8 inches of bedding material unless otherwise specified on the Drawings. Where, in the opinion of the Engineer, more than 8 inches of bedding material shall be required, the excavation shall be performed and bedding placed to the depth ordered by the Engineer.

D. Provide uniform bearing and support for each section of pipe at every point along the entire length except where necessary to excavate for bell holes, pipe joints, or other required connections. Dig bell holes and depressions for joints after trench bottom has been graded. Dig no deeper, longer, or wider than needed to make the joint connection properly.

E. The bedding material shall be placed to the full width of trench. The bedding material shall be placed in loose lifts not exceeding 6 inches to the elevation shown on the Drawings or directed

by the Engineer. The bedding material shall be tamped and compacted to form a firm and even bearing surface.

F. Pipe zone backfill shall be placed to the elevation shown on the Drawings in loose lifts not-to-exceed 6 inches in thickness, before compaction. The backfill shall be placed on both sides of the pipe at the same time and to approximately the same elevation. Any pipe that is damaged or moved out of alignment, regardless of cause, shall be replaced or realigned at the Contractor's expense. Each layer shall be thoroughly compacted by hand-tamping or mechanical means being careful not to damage the pipe. When the pipe zone backfill reaches 1 foot over the top of the pipe, the entire surface shall be compacted by mechanical means.

G. The remainder, if any, of the trench above the pipe zone backfill shall be backfilled with suitable material in loose lifts not exceeding 6 inches in thickness before compaction. Each layer shall be thoroughly compacted by mechanical means.

3.5 BACKFILLING AROUND STRUCTURES

A. The Contractor shall not place backfill against any structure without obtaining the approval of the Engineer. No dumping shall be allowed where materials would flow against or around such structures. Backfill material shall be deposited in horizontal layers not exceeding 6 inches in loose thickness or as shown on the Drawings and thoroughly compacted by hand or by mechanical means to the satisfaction of the Engineer.

3.6 SUSPENSION OF WORK

A. Whenever the work is suspended, excavations shall be protected and the roadways, if any, left unobstructed. Within or adjacent to private property, material shall be stored at such locations as will not unduly interfere with traffic of any nature and in no case shall materials be stored in locations which will cause damage to existing improvements.

3.7 DISPOSAL OF MATERIAL

A. Excess and unsuitable materials shall be disposed of by the Contractor on the site in an area approved by the Engineer or legally disposed of off- site at the Contractor’s expense.

3.8 FIELD QUALITY CONTROL

A. Notify the Engineer at least 3 working days in advance of all phases of filling and backfilling operations.

B. In-place density testing shall be performed to ascertain the compacted density of the fill and backfill materials in accordance with the following methods:
   1. In-place relative density:
      a. Method: AASHTO T310, Nuclear Method.

C. Perform initial density testing to verify that contractors proposed compaction effort will obtain the minimum required densities.

D. In-place density tests on trench backfills shall be provided for every 500 cubic yards of fill or in vertical lifts not exceeding 2 feet and at least once daily.

E. One particle size analysis (ASTM D422) and one modified Proctor compaction test (ASTM D1557) shall be competed for every 5,000 cubic yards of material placed.

F. The Engineer may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions, at the Contractor's expense.

G. Acceptance Criteria: The criteria for acceptability of in-place fill shall be in-situ dry density and moisture content. If a test fails to qualify, the fill shall be further compacted and re-tested. Subsequent test failures shall be followed by removal and replacement of the material.

END OF SECTION 312333

SECTION 312500 – EROSION AND SEDIMENT CONTROL

PART 1 – GENERAL

1.1 SUMMARY

A. This Section covers work necessary for stabilization of soil to prevent erosion and sedimentation during and after construction and land disturbing activities. The work shall include the furnishing of all labor, materials, tools, and equipment to perform the work and services necessary as herein specified and as indicated on the Drawings. This shall include installation, maintenance, and final removal of all temporary soil erosion and sediment control measures. All erosion and sediment control methods and devices used shall conform to the latest requirements imposed by federal, state, and local authorities.

B. Comply with SPDES General Permit GP-0-20-001 for stormwater discharges from construction activities and the Stormwater Pollution Prevention Plan prepared for the project. (Attached at the end of this Section.)

C. Comply with the latest version of New York State Standards and Specifications for Erosion and Sediment Control

D. The minimum areas requiring soil erosion and sediment control measures are indicated on the Drawings. The right is reserved to modify the use, location, and quantities of soil erosion and sediment control measures based on activities of the Contractor and as the Engineer considers to be the best interest of the Owner.

E. The Contractor shall be responsible for repair of any damage caused and shall be financially responsible for any penalties imposed.

1.2 QUALITY ASSURANCE

A. Soil erosion and sediment control measures shall be implemented in accordance with the requirements and procedures outlined in this Specification, Contract Drawings and documents, state standards or guidelines for soil erosion and sediment control, and all regulatory authorities having jurisdiction. Where conflicts between requirements exist, the more restrictive rules shall govern.

B. The Contractor shall provide all temporary control measures shown on the Drawings, or as directed by the Owner, Owner's representative, or soil conservation district for the duration of the contract. Erosion and sediment control Drawings are intended to be a guide to address the stages of work shown. Additional measures not specified on the Drawings may be necessary and shall be implemented to address intermediary stages of work and any conditions that may develop during construction at no cost to the Owner.

C. Temporary control provisions shall be coordinated with permanent erosion control features to the extent practical to assure economical, effective, and continuous erosion and sediment control throughout the construction and post-construction period.

D. Soil erosion and sediment control measures shall at all times be satisfactory to the Owner's Representative. Owner's Representative will inform the Contractor of unsatisfactory construction procedures and operations if observed. If the unsatisfactory construction procedures and operations are not responded to and corrected within 48 hours, the Owner's Representative may suspend the performance of any or all other construction until the unsatisfactory condition has been corrected. Such suspension shall not be the basis of any claim by the Contractor for additional compensation nor for an extension of time to complete the work. Any complaints, fines, etc. relating to ineffective erosion control, shall be the sole responsibility of the Contractor.

E. The Contractor shall inspect all soil erosion and sediment control measures at least at the beginning and end of each day to ascertain that all devices are functioning properly during construction. Maintenance of all soil erosion and sediment control measures on the project site shall be the responsibility of the Contractor until final stabilization is complete, and until the permanent soil erosion controls are established and in proper working condition.

F. The Contractor shall protect adjacent properties and watercourses from soil erosion and sediment damage throughout construction.

1.3 GENERAL

A. Soil erosion stabilization and sediment control measures consist of the following elements:
1. Maintenance of existing permanent or temporary storm drainage piping and channel systems, as necessary.
2. Installation and maintenance of stabilized construction entrance(s).
3. Construction of new permanent and temporary storm drainage piping and channel systems, as necessary.
4. Construction of temporary erosion control facilities such as silt fences, check dams, etc.
5. Topsoil and Seeding: Placement and maintenance of Temporary Seeding on all areas disturbed by construction. Placement of permanent topsoil, fertilizer, and seed, etc., in all areas not occupied by structures or pavement unless shown otherwise.
6. Soil Stabilization Seeding: Placement of fertilizer and seed, etc., in areas as Specified hereinafter.

B. The Contractor shall he responsible for phasing Work in areas allocated for his exclusive use during this Project, including any proposed stockpile areas, to restrict sediment transport. This will include installation of any temporary erosion control devices, ditches, or other facilities.

C. The areas set aside for the Contractor's use during the Project may be temporarily developed to provide satisfactory working, staging, and administrative areas for his exclusive use. Preparation of these areas shall be in accordance with other requirements contained within these Specifications and shall he done in a manner to both control all sediment transport away from the area.

D. Stockpiles remaining in place longer than 14 calendar days shall be considered permanent stockpiles for purposes of erosion and sediment control.

E. All permanent stockpiles shall be seeded with soil stabilization seed and protected by construction of silt fences completely surrounding stockpiles and located within 10 feet of the toes of the stockpile slopes.

F. Sediment transport and erosion from working stockpiles shall be controlled and restricted from moving beyond the immediate stockpile area by construction of temporary toe-of-slope ditches and accompanying silt fences as necessary. The Contractor shall keep these temporary facilities in operational condition by regular cleaning, regrading, and maintenance.

G. The Contractor shall maintain all elements of the Soil Erosion Stabilization and Sedimentation Control systems and facilities to be constructed during this Project for the duration of his activities on this Project.

1.4 SUBMITTALS

A. Submittals shall he made in accordance with Section 013300 "Submittal Procedures."

B. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements.

C. Results of all tests and investigations, including recommendations.

D. Submit product data, samples, specifications and manufacturer’s installation procedures for approval as directed by Owner’s Representative prior to use.

PART 2 – PRODUCTS

2.1 GENERAL

A. Contractor shall provide all materials necessary to perform the work in accordance with the SWPPP or as shown on the Drawings or specified herein.

2.2 PERMANENT SEED

A. Refer to Section "Turf and Grasses."

2.3 SOIL STABILIZATION AND TEMPORARY SEED

A. Temporary Seed: Rye grass, cereal grasses, or other quick growing species suitable to the area as a temporary cover, which will not compete with the grasses specified for permanent cover or as specified in the SWPPP or on the Drawings.

2.4 TOPSOIL

A. Topsoil shall be as specified under Section "Soil Preparation."

2.5 FERTILIZER

A. Refer to Section "Turf and Grasses."

2.6 LIME

A. Ground dolomite limestone not less than 85 percent total carbonates and magnesium, ground so that 50 percent passes through a No. 100 mesh sieve and 90 percent passes a No. 20-mesh sieve. Coarser material will be acceptable provided the specified rates of application are increased proportionately on the basis of quantities passing the No. 100-mesh sieve.

2.7 STRAW MULCH

A. Threshed straw of oats, wheat, barley, or rye, free from seed of noxious weeds or clean salt hay.

2.8 EROSION CONTROL BLANKET

A. Erosion Control Blanket (ECB) shall be constructed with a layer of 70 percent straw and 30 percent coconut fiber stitched with degradable thread between a heavyweight UV stabilized polypropylene top net (3 pounds) and a lightweight photodegradable polypropylene bottom net (1.50 pounds). Both the netting and fiber material shall be green in color. Acceptable products shall include SC150 Double Net Straw-Coconut Blanket as manufactured by North American Green; Curlex Double Net (Curlex II) as manufactured by American Excelsior Company or an approved equal.

2.9 TURF REINFORCEMENT MATS

A. Permanent Synthetic Turf Reinforcement Mat (TRM) shall be constructed of UV stabilized polypropylene fiber (0.70 pounds per square yard) stitched with permanent polypropylene thread between heavyweight UV stabilized polypropylene top net (5 pounds per 1000 square feet approximate weight) and bottom net (3 pounds per 1000 square feet approximate weight). Both the netting and fiber material shall be green in color.

B. Acceptable products shall include P300 Permanent Turf Reinforcement Mat as manufactured by North American Green; Recyclex TRM by American Excelsior Company or an approved equal.

2.10 HAY BALE

A. Bales shall be tightly bound, staked with 1 inch by 1 inch hardwood stakes. Hay shall be from mowings of acceptable herbaceous growth free from noxious weeds.

2.11 STONE CHECK DAM

A. The gradation of stone check dam material identified on the plans shall meet the following requirements:

NCSA ROCK SIZE*	PERCENT PASSING BY WEIGHT
12"	100
6"	15 – 50
3"	0 – 15

*National Crushed Stone Association

B. Geotextile fabric for stone check dam shall meet the requirements non-woven fabric found in Section "Geotextiles."

2.12 SILT FENCE

A. Silt Fence (SF) shall consist of woven geotextile fabric, posts, wire mesh backing, and fasteners meeting the requirements shown on the Drawings.

B. The woven geotextile fabric shall meet the following specifications.

Fabric Properties	Minimum Acceptable Value	Test Method
Grab Tensile Strength (lbs.)	110	ASTM D 4632
Elongation at Failure (%)	20	ASTM D 4632
Mullen Burst Strength (PSI)	300	ASTM D 3786
Puncture Strength (lbs)	60	ASTM D 4833
Minimum Trapezoidal Tear Strength (lbs)	50	ASTM D 4533
Flow Through Rate (gal/min/sf)	25	ASTM D 4491
Equivalent Opening Size	40-80	ASTM D 4751
Minimum UV Residual (%)	70	ASTM D 4355

2.13 COMPOST FILTER SOCK

A. Compost infill shall consist of decomposed (matured at least 3 months), weed-free, organic material that is aerobically composted, possess no odors, and contain less than 1%, by dry weight, of man-made material. The compost infill should meet the following specifications. All biosolids compost produced in New York State must meet NYS DEC's 6 NYCRR Part 360 (Solid Waste Management Facilities) requirements or more stringent than 40 CFR Part 503 to ensure safe standards for pathogen reduction and heavy metal content.

Organic Matter Content	25% - 100% (dry weight)
Organic Portion	Fibrous and elongated
pH	6.0 – 8.0
Moisture Content	30% - 60%
Particle Size	100% passing a 1” screen and 10-50% passing a 3/8” screen
Soluble Salt Concentration	5.0 dS/m (mmhos/cm) maximum

B. Compost filter sock fabric material shall meet the minimum requirements and specifications listed in the following tables.

MATERIAL TYPE	**3 MIL HDPE**	**5 MIL HDPE**	**5 MIL HDPE**	**MULTI-FILAMENT POLYPROPYLENE (MFPP)**	**HEAVY DUTY MULTI-FILAMENT POLYPROPYLENE (HDMFPP)**
MATERIAL CHARACTERISTICS	PHOTODEGRADABLE	PHOTODEGRADABLE	BIODEGRADABLE	PHOTODEGRADABLE	PHOTODEGRADABLE
SOCK DIAMETERS	12”,18”	12”, 18”,24”, 32”	12”, 18”,24”, 32”	12”, 18”,24”, 32”	12”, 18”,24”, 32”
MESH OPENING	3/8”	3/8”	3/8”	3/8”	1/8”
TENSILE STRENGTH		26 PSI	26 PSI	44 PSI	202 PSI
ULTRAVIOLET STABILITY % ORIGINAL STRENGTH (ASTM G-155)	23% AT 1000 HR.	23% AT 1000 HR.		100% AT 1000 HR.	100% AT 1000 HR.
MINIMUM FUNCTIONAL LONGEVITY	6 MONTHS	9 MONTHS	6 MONTHS	1 YEAR	2 YEARS

2.14 MANUFACTURED INSERT INLET PROTECTION

A. The sack structure shall consist of woven geotextile fabric equal to or exceeding the performance standard for the silt fence fabric.

PART 3 – EXECUTION

3.1 GENERAL

A. The Contractor shall comply with and implement the Stormwater Pollution Plan provided in the contract documents.

B. Review the soil erosion and sediment control Drawings as they apply to current conditions. Any deviation from the Drawings must be submitted for approval to the site Engineer in writing at least 72 hours prior to commencing that work.

C. Initial soil sediment and erosion control devices shall be in place prior to any land disturbing activity in their proper sequence and maintained until permanent protection is established.

D. The limit of the area of any earthwork operations in progress shall be commensurate with the Contractor's capability and progress in keeping the finished grading, mulching, seeding, and other such permanent control measures current and in accordance with the accepted schedule for construction phasing. Should seasonal limitations make such coordination unrealistic, as determined by the Owner's Representative, temporary erosion control measures shall be provided immediately by the Contractor at no expense of the Owner.

E. Temporary erosion control measures shall be used to correct conditions which develop during construction that are needed prior to installation of permanent control features, or that are temporarily needed to control erosion that develops during normal construction practices but are not associated with permanent control features on the project.

F. The Contractor shall incorporate all permanent erosion control features (stabilization) into the project at the earliest practical time to minimize the need for temporary controls.

G. A stabilized construction entrance (SCE) shall be installed and maintained at any point where construction vehicles enter a public right-to-way, street, or parking area. The SCE shall be used to eliminate mud from the construction area onto public right-of-way. The SCE shall be constructed as shown on the Drawings. Any mud or debris tracked on streets shall be cleaned up immediately.

H. Dust Control: The Contractor shall provide a commercial grade; enclosed broom mechanical street sweeper to control sediment and/or dust that is tracked on to the adjacent streets. The street sweeper shall be equipped with a water storage tank to wet the area prior to sweeping. Where on site controls do not prevent material from being tracked on to adjacent streets, the street sweeper shall be used to clean the adjacent streets immediately. In addition, at a minimum, the adjacent streets shall be swept at the end of each day or as directed by the Engineer.

I. Any disturbed or stockpiled areas that will be left exposed more than 14 days or less according to State NPDES General Stormwater Permits shall immediately receive temporary or permanent seeding. Mulch/straw shall be used if the season prevents the establishment of a temporary cover. Disturbed areas shall be limed and fertilized prior to temporary seeding.

J. Permanent vegetation shall be established as specified on all exposed areas within 7 days or less according to State NPDES General Stormwater Permits after final grading. Mulch as necessary for seed protection and establishment. Lime and fertilize seedbed prior to permanent seeding.

K. Slopes shall be permanently seeded and mulched. Any slopes that erode easily shall be temporarily seeded and mulched. Any slopes deeper than 3:1 or steeper or as indicated on Drawings shall be protected with Erosion Control Blanket per specifications.

L. All storm drainage outlets must be stabilized, as specified, before the discharge points become operational. Equip all inlets with inlet protection immediately upon construction.

M. Manufactured insert inlet protection shall be installed and anchored in accordance with the manufacturers recommendations and design details. The Contractor shall maintain all manufactured insert inlet protection units until the project is stabilized and shall remove and dispose of the sediment accumulation properly when the units are more than 1/3 full. Replace and reinstall the unit if necessary.

N. Discharge from dewatering operations for the excavated areas shall not be directed to surface waters without first properly removing the suspended sediment through filtration and/or settlement. The Contractor shall obtain any required permits associated with dewatering activities.

O. Silt fence shall be installed at locations on the Drawings and any additional locations necessary for proper sediment control. The Contractor shall maintain the silt fence until the project is stabilized and shall remove and dispose of the silt fence and silt accumulation when 1/3 the height of the fence is reached.

P. Filter Socks shall be place at locations indicated on plans or as directed by the Engineer. They should be installed parallel to the base of the slope or other affected area. The Contractor shall maintain the Filter Socks and they shall be inspected weekly and after each rain event. If the Filter Sock requires repair, it shall be repaired in accordance with the manufacture's recommendations or replaced within 24 hours of inspection notification. Biodegradable filter socks shall be replaced after 6 months; photodegradable filter socks after 1 year. Polypropylene socks shall be replaced according to the manufacturer's recommendations.

Q. Soil erosion and sediment control shall include but not be limited to the approved measures. The Contractor shall be responsible for providing all additional measures that may be necessary to accomplish the intent of the Drawings.

R. Comply with all other requirements of authorities having jurisdiction.

S. Soil Stabilization and Temporary Seeding:

1. Soil stabilization seeding shall consist of the application of the following materials in quantities as further described herein for stockpiles and disturbed areas left inactive for more than 14 days.
    a. Lime.
    b. Fertilizer.
    c. Seed.
    d. Mulch.
    e. Maintenance.
2. Hydroseeding will be permitted as an alternative method of applying seed and associated soil conditioning agents described above. Should the Contractor elect to apply soil stabilization seeding by hydroseeding methods, he shall submit his operational plan and methods to the Engineer.

3. Temporary Seeding is to be placed and maintained over all disturbed areas prior to Permanent Seeding. Maintain Temporary Seeding until such time as areas are approved for Permanent Seeding. As a minimum, maintenance shall include the following:
   a. Fix-up and reseeding of bare areas or re-disturbed areas.
   b. Mowing for stands of grass or weeds exceeding 6 inches in height.

T. Topsoil and Permanent Seeding: conform to the requirements of Section "Soil Preparation" and Section "Turf and Grasses."

END OF SECTION 312500

SECTION 313710 – STONE FILL

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes provisions for the placement of stone fill on embankment slopes, drainage courses, culvert inlet's and outlets, and streambanks.

1.2 REFERENCES

A. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering."

B. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."

1.3 SUBMITTALS

A. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements.

B. Results of all tests, investigations, including recommendations.

C. Manufacturer's catalog cuts, production data, and recommended installation procedures for geotextile fabric.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Stone fill shall conform with NYSDOT Section 733.21 and shall meet the following gradation requirements:

1. Fine:

STONE FILL	PERCENT OF TOTAL BY WEIGHT
<8 inches	90 – 100
>3 inches	50 - 100
<#10 sieve	0 – 10

2. Light:

STONE FILL	PERCENT OF TOTAL BY WEIGHT
<100 pounds	90 – 100
>6 inches	50 – 100
<1/2 inches	0 – 10

B. Bedding shall conform with NYSDOT Section 733.23 and shall meet the following gradation requirements:

STONE FILL	PERCENT PASSING BY WEIGHT
4 inches	100
1 inch	15 – 60
1/4 inch	0 – 25
No. 40	0 – 10

C. Geotextile: Shall conform to the requirements of Section "Geotextiles."

PART 3 – EXECUTION

3.1 SURFACE PREPARATION

A. Clear the surface on which the riprap is to be placed of brush, trees, or other objectionable material.

3.2 INSTALLATION

A. Geotextile Fabric: Shall be installed in conformance with the requirements of Section "Geotextiles."

B. Bedding:
1. Place the bedding material on the geotextile to the full thickness, 6-inch minimum, in one operation using methods that will not cause segregation of the aggregate.
2. Prevent contamination of bedding material by natural soils or other materials. Remove bedding materials that become contaminated and replace with uncontaminated bedding material.
3. Do not drop bedding material onto the geotextile from a height exceeding 3 feet.

C. Stone Fill:
1. Place the stones so that the dimension approximately equal to the layer thickness is perpendicular to the slope surface such that the weight of the stone is carried by the underlying material, not by the adjacent stones.
2. Place stone fill to minimize void spaces between adjacent stones.
3. On slopes the largest stones shall be placed at the bottom of the slope.
4. Place stone fill to avoid disruption and damage to the bedding material.

END OF SECTION 313710

SECTION 316100 - FOOTINGS

PART 1 - GENERAL

1.1 GENERAL

Work of this Section shall conform to requirements of Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections.

1.2 SCOPE

The work covered by this Section shall include all labor, material, equipment, permits, engineering and other services necessary for the fabrication and installation of footings and related work, complete, in accordance with the Drawings and as specified herein.

1.3 RELATED WORK SPECIFIED IN OTHER SECTIONS

Submittals	Division 1
Quality Control	Division 1
Quality Assurance: Structural Testing and Inspection	Section 014500
Concrete Reinforcement	Section 032000
Cast-In-Place Concrete	Section 033000
Thermal and Moisture Protection	Division 7

1.4 CODES AND STANDARDS

A. Building Code: Footing work shall conform to the requirements of the Building Code identified on the structural General Notes, and OSHA requirements, except where more stringent conditions or criteria occur in the standards referenced below and on the Drawings.

B. Standards:

1. ACI 117 – Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 301 – Standard Specifications for Structural Concrete.
3. ACI 315 – Details and Detailing of Concrete Reinforcement.
4. ACI 318 – Building Code Requirements for Reinforced Concrete.
5. American Concrete Institute “Manual of Concrete Practice”, various committee reports as referenced herein.
6. American Society for Testing and Materials "ASTM Standards in Building Codes", various standards as referenced herein.
7. AWS D1.4 – Structural Welding Code-Reinforcing Steel.

C. Definitions:

1. See Section 033000.
2. The term Owner’s Geotechnical Engineer in this Specification is defined as the Owner’s representative specifically authorized to perform the responsibilities defined herein.

1.5 CONTRACTOR QUALIFICATIONS

A. The Footing Installer shall be a company which specializes in installing footings, with a minimum of 10 years of documented successful experience. Installation shall be performed by skilled workmen thoroughly experienced in the necessary execution.

B. The Contractor's Field Supervisor shall have 10 years of experience in installing footings and provide full-time supervision.

C. The Contractor's Professional Surveyor shall have 10 years of previous experience in laying out foundation locations to perform surveys, layouts, and measurements for footing work. The Contractor's Professional Surveyor shall be licensed in the state where the project is located. Conduct layout work for each footing to lines and levels required before excavation, and actual measurements of each footing's horizontal location, top elevations, deviations from specified tolerances, and other required data.

1.6 SUBMITTALS

A. Required Submittals - Where the SUBMITTALS section of this Specification is in conflict with Division 1 Submittals, the more stringent requirements for the Contractor apply. Required submittal items are listed here; see below for detailed requirements. Do not submit items not requested.

(1) Submittal Schedule
(2) Footing Construction Methods
(3) Installer Qualifications
(4) Shop drawings
(5) Construction Log
(6) Contractor's Survey Report
(7) Submittals required by Related Documents
(8) Mill Certificates
(9) Owner's Concrete Testing Agency Reports
(10) Product Data

1. Submittal Schedule: See Section 033000.
2. Footing Construction Methods: Submit for record, footing construction procedures developed by the Footing Contractor.
3. Installer Qualifications: Submit proof of qualifications as stated in the CONTRACTOR QUALIFICATIONS section of this Specification.
4. Shop drawings in accordance with 032000 and 033000, and as noted.

    a) Concrete mix designs in accordance with Section 033000.
    b) Footing reinforcement in accordance with Section 032000 and 033000.
    c) Footing layout drawing showing the location of each footing (with respect to building gridlines), size and depth of footing, and top of footing elevation.

5. Construction Log: Testing Agency shall document, sign, and submit for record, a record of each footing construction, including:

    a) Footing designation, top and where possible bottom elevation, and size of footing.

b) Size, length, and location of installed reinforcement.
c) Deviation of centerline plan location.
d) Actual allowable soil bearing capacity
e) Inspection and testing
f) Method of concrete placement, time of beginning and ending concrete discharge for each truck, (including any delays in concreting and location of construction joints in shafts) and any deviation from planned construction methods.
g) Volume of concrete supplied to footing and ratio of actual volume to theoretical volume.

6. Contractor's Survey Report: Submit for record plans sealed and signed by a Professional Surveyor licensed in the state where the project is located, indicating as built plan locations of footing centerlines (with respect to building gridlines), top and where possible bottom elevations, and identifying deviations of footing centerlines from design plan locations. Footings that are outside of specified tolerances shall be specifically identified on the plan.
7. Submittals required by Related Documents.
8. Mill Certificates: Per Specification section 032000, submit for record certified reports for physical and chemical properties of following materials:

   a) Reinforcement bars.

9. Owner's Concrete Testing Agency Reports: Submit for record

   a) Reports of field observations.
   b) Reports of field quality control tests, as related to concrete and reinforcement.
   c) Immediately notify the Design Professionals of any deviations from the Drawings.

10. Product Data: Submit for record for each type of product identified in Part 2. Product Data shall be clearly marked to indicate all technical information which specifies full compliance with this section and Contract Documents, including published installation instructions and ICC reports, where applicable, for products of each manufacturer specified in this section.

B. Submittal Process: See Section 033000.

C. SER Submittal Review: See Section 033000.

D. Substitution Request: See Section 033000.

E. Request for Information (RFI): See Section 033000.

1.7 DELIVERY, STORAGE, AND HANDLING

A. See Sections 032000 and 033000.

1.8 PRE-INSTALLATION CONFERENCE

A. Conduct meeting at Project Site to comply with requirements in Division 1.

1.9 PROJECT SITE CONDITIONS

A. Geotechnical Information: Contractor to examine site, records of test borings, soil samples, and Geotechnical Reports that are available from the Owner. Soil boring test results are provided by the Owner for information, and are not guaranteed to represent conditions that are present at footing locations. Soil boring test results are not intended as representations or warranties of the continuity of the reported conditions. It is expressly understood that the Owner will not be responsible for interpretation or conclusions drawn by Contractor from the Geotechnical Report. At no additional cost to the Owner, evaluate the available data and provide additional test borings and other investigations as necessary for installing footings.

B. Site Survey: Survey of site, existing utilities, and existing construction available from the Owner represent conditions known to Owner. Other obstructions may be encountered.

1.10 QUALITY ASSURANCE BY OWNER'S TESTING AGENCY

A. See Section 014500.

1.11 QUALITY CONTROL BY CONTRACTOR

A. See Section 033000.

B. The Contractor's Geotechnical Engineer shall be qualified to perform the type of work required by the Project. The Engineer shall be a Licensed [Professional/Structural/Geotechnical] Engineer in the state where the project is located. The engineer shall develop a site dewatering plan and advise on footing construction techniques, including assistance in the development of construction procedures and the development of solutions to construction problems.

1.12 OBSERVATIONS AND CORRECTIONS BY DESIGN PROFESSIONALS

A. See Section 033000.

1.13 PERMITS AND WARRANTY

A. Permits: See Section 033000.

Drawings and calculations prepared by the Contractor's Licensed [Professional/Structural/Geotechnical] Engineer in the state where the project is located for temporary shoring and/or earth retention shall be submitted to the City, State, or other governing authority for review.

B. Warranty: See Section 033000.

PART 2 - PRODUCTS

2.1 CONCRETE

A. See Section 033000.

2.2 REINFORCEMENT

A. See Section 032000.

PART 3 - EXECUTION

3.1 PROTECTION OF EXISTING UTILITIES AND STRUCTURES

A. Before installing footings adjacent to known existing utilities, notify utility owner to ensure that protective work will be coordinated and performed by Contractor in accordance with requirements of the owner of utility or building. If any existing service lines, utilities, and utility structures to remain in service are uncovered or encountered during work, protect the uncovered element from damage and provide support where necessary.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during footing excavation, immediately notify the Owner, Design Professionals and utility owner. Cooperate with Owner and utility owner in keeping their respective services, utilities and facilities in operation. Repair damaged utilities to entire satisfaction of Owner and utility owner concerned.

C. Do not interrupt existing utility service facilities occupied and used by Owner and others, except when permitted in writing by the Design Professionals and then only after acceptable temporary utility services have been provided.

D. Protect structures, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by footing operations.

3.2 SITE DEWATERING

A. Before installing footings, provide site dewatering based on the Contractor’s site dewatering plan.

B. Provide and maintain pumping equipment to keep excavations free of water before placing concrete. If excessive water is encountered and drilling operations must be halted, consult the Geotechnical Engineer before using alternate methods of construction.

C. If excessive seepage is coming in from below the bottom of the footing excavation, removal by pumping within the excavation is inappropriate, as this may loosen the bearing soils and reduce the bearing soil capacity; therefore, an alternate means of dewatering will be required.

3.3 GENERAL FOOTING EXCAVATION

A. Tolerances: Plan location tolerance is 2% of footing dimension but no greater than 2 inches (50 mm), whichever is greater, If indicated tolerances are exceeded, see “Footing Corrective Measures” in Part 3.

B. Forming Sides of Footings:

1. Provide forms for footings and grade beams if soil or other conditions are such that earth trench forms are unsuitable.
2. When trench forms are used, provide an additional 1” (25 mm) of concrete on each side of the minimum design profiles and dimensions indicated.
3. Earth forming of concrete elements is not acceptable.

C. Cleanup of Footing Bottom: Excavate bottom to a level plane. Remove loose materials or free water as determined by Owner's Geotechnical Engineer.

D. Bottom of adjacent footings that are at different elevations should never result in an excavation slope between footings greater than 1.0 vertical to 1.5horizontal unless otherwise noted in the drawings or geotechnical engineering report. If steeper slopes occur, the EOR should be notified before any concrete is placed.

3.4 ADDITIONAL EXCAVATION AND FOOTING DEPTH

A. Do not excavate below elevations noted by Owner's Geotechnical Engineer without prior review by Owner's Geotechnical Engineer.

B. Where Owner's Geotechnical Engineer determines that soil encountered at design bearing elevation is not capable of providing minimum design bearing capacity, perform additional excavation as recommended by Owner's Geotechnical Engineer.

C. If obstructions are encountered that interfere with new construction, remove such existing elements or develop corrective methods. The Contractor shall propose corrective actions and their recommendations in writing and submit them for review by the Design Professionals. Efforts shall be made to address obstructions at no additional cost to the Owner.

3.5 DISPOSAL OF EXCAVATED MATERIALS

Dispose excavated materials off site in a manner that will not interfere with other construction activities. Keep construction site at all times clean and free of soil and other debris that could affect progress of other construction activities.

3.6 FOOTING REINFORCEMENT

A. Fabrication in accordance with 032000 from approved shop drawings.

3.7 FOOTING BEARING STRATA

A. Footing Bearing Stratum Criteria and Verification

1. Footings shall be founded on soil strata with bearing capacity indicated on Drawings. Footings shall not be excavated until test results by Owner's Geotechnical Engineer confirm allowable bearing values indicated on Drawings, but shall be excavated immediately thereafter.
2. Each footing bearing strata must be inspected and be acceptable to the Owner's Geotechnical Engineer before placing concrete
3. Footing excavations to acceptable bearing strata shall not be left exposed to weather for more than 48 hours before footing concrete is placed.
4. At no time before or after footing concrete is placed shall the soil below the footing be allowed to freeze. Adequate freeze protection must be sufficient depth to provide adequate frost protection per the geotechnical engineering report.

3.8 CORRECTIVE MEASURES

A. If unforeseen field conditions require corrective installation methods, immediately notify the Design Professionals.

1. Where a change to the construction installation method result in an as-built footing in compliance with the Contract Documents, submit installation method for record.
2. Where the as-built footing does not meet the design intent of the Contract Documents. The Contractor shall propose corrective actions and their recommendations in writing and submit them for review by the Design Professionals.

B. If footings are installed outside allowable tolerances, develop and provide corrective methods at no extra cost to the Owner including calculations based on actual locations of footings, taking into account eccentricity between final centerline of footing and design location of column centerline. The Contractor shall propose corrective actions and their recommendations in writing and submit them for review by the Design Professionals. Calculations shall be sealed and signed by a [Professional/Structural/Geotechnical] Engineer licensed in the state where the project is located.

C. Where the Contractor requests that the Design Professionals develop the corrective actions or review corrective actions developed by others, the Design Professional shall be compensated as outlined in Part 3 – CORRECTIVE MEASURES section of Specification 033000.

END OF SECTION

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SECTION 321116 – SUBBASE COURSES

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes provisions for prepared subbase courses for under walks and pavements.

B. Proof rolling of subgrade for walks and pavements is included in this Section.

C. Replacement of unsuitable subgrade materials is included in another Section.

D. Final grading of pavement subbase is specified in this Section.

E. Stabilization fabric is included in another Section.

1.2 REFERENCES

A. The latest edition of the following standards, as referenced herein, shall be applicable:
   1. Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering.
   2. Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).
   3. American Society for Testing and Materials (ASTM).

1.3 SUBMITTALS

A. Source Quality Control Test Reports: Submit test reports directly to Engineer from the testing agency with copy to Contractor.

B. Field Testing Reports: Submit results of field testing directly to Engineer with copy to Contractor. Reference testing location to plan, and cross-reference to all retesting required to accept installed subbase material.
   1. Note action taken next to all sub-standard test results.

1.4 QUALITY ASSURANCE

A. Testing Laboratory Qualifications: To qualify for acceptance, the soil testing laboratory must demonstrate to Engineer's satisfaction, based on evaluation of laboratory-submitted criteria conforming to ASTM E699, that it has the experience and capability to conduct the required testing without delaying the progress of the Work.

B. Field Testing and Inspection Service: Contractor shall retain the services of the same independent soil testing laboratory used for source qualification testing to provide soil testing during pavement subbase installation.

PART 2 – PRODUCTS

2.1 OPTIONAL TYPES:

A. Select one of the following subbase options:
1. Option A: Subbase courses consisting of a layer of Type 3 subbase material followed by a layer of Type 4 subbase material. The upper layer of Type 4 subbase material shall be at least four inches thick, after compaction.
2. Option B: Subbase course consisting of a single layer of Type 1 subbase material.
3. Option C: Subbase course consisting of a single layer of Type 2 subbase material.
4. Option D: Subbase course consisting of a single layer of Type 4 subbase material.

2.2 SOURCE QUALIFICATION TESTING

A. Contractor shall employ and pay for a qualified independent soil testing laboratory to perform soil testing services for source qualification.
1. Obtain a 100-pound minimum representative sample from each potential aggregate source. Obtain samples for each different material gradation known to exist in the pit. Mix each sample thoroughly in accordance with AASHTO T87 and submit to the testing laboratory for reduction to specimen size. The laboratory shall perform the following tests in the order shown. Each material shall pass all tests in order to qualify.
a. Particle Size Analysis:
1) Method: ASTM D422.
2) Number of Tests: 2 per potential source.
3) Acceptance Criteria: Gradation within specified limits.
b. Plasticity Index Determination:
1) Method: ASTM D424.
2) Number of Tests: 1 particle size analysis on material passing no 40 mesh.
3) Acceptance Criteria: Plasticity Index within specified limits.
c. Maximum Density Determination:
1) Method: ASTM D1557 Modified Proctor.
2) Number of Tests: 2 per potential source.
d. Magnesium Sulfate Soundness Loss Test:
1) Method: NYSDOT Standard Test Method 11.
2) Number of Tests: 2 per potential source.
3) Acceptance Criteria: 4 cycle loss within specified limits.
2. Re-establish subbase material properties if source is changed during construction.

2.3 MATERIALS

A. Processed Gravel Subbase Course: Materials shall consist of sound, durable blast furnace slag, stone, sand, gravel, or blends of these materials.

B. Crushed Rock Subbase Course: Materials shall consist solely of approved blast furnace slag or stone which is the product of crushing ledge rock (NYSDOT Type 2).

C. All materials shall be well graded from course to fine and free from organic or other deleterious materials, conforming to the requirements of NYSDOT Section 304, and meeting the following gradation requirements:

TYPE	SIEVE	PERCENT PASSING
1	3"	100
	2"	90-100
	1/4"	30-65
	No. 40	5-40
	No. 200	0-10
2	2”	100
	1/4"	25-60
	No. 40	5-40
	No. 200	0-10
3	4”	100
	1/4"	30-75
	No. 40	5-40
	No. 200	0-10
4	2”	100
	1/4"	30-65
	No. 40	5-40
	No. 200	0-10

1. Magnesium Sulfate soundness loss after 4 cycles shall be less than 20 percent for types 1, 2, and 4. Magnesium sulfate soundness loss after 4 cycles shall be less than 30 percent for type 3.
2. Plasticity Index of material passing No. 40 sieve shall not exceed 5.0.
3. Not more than 30 percent, by weight, of the particles retained on a 1/2-inch sieve shall consist of flat or elongated particles. A flat or elongated particle is defined as one which has its greatest dimension more than 3 times its least dimension.
4. All material shall meet the specified gradation prior to placement. All processing shall be completed at the source.
5. Stabilization Fabric: Conform to Section "Geotextiles."

D. Material substitutions and/or additives such as glass, Blast Furnace Slag, Recycled Portland Cement Concrete Aggregate (RCA) and Reclaimed Asphalt Pavement shall be allowed for Types 1, 3 and 4, in accordance with NYSDOT Section 304 and are subject to approval and acceptance by the Engineer.

PART 3 – EXECUTION

3.1 PREPARATION

A. Establish required lines, levels, contours, and datum.

B. Maintain benchmarks and other elevation control points. Re-establish, if disturbed or destroyed, at no additional cost to Owner.

C. Proof-roll existing subgrade to the satisfaction of the Engineer. Should the subbase course become unstable at any time prior to the placement of the overlying course(s), correct the unstable condition to the satisfaction of the Engineer. Replace unstable or weak subgrade materials with suitable material as provided in the Specifications.

D. Place stabilization fabric in locations as directed on the plans and in accordance with Section "Geotextiles" after subgrade has been proof-rolled and accepted by the Engineer.

3.2 INSTALLATION

A. Place subbase material in uniform horizontal layers, with a maximum compacted thickness of 12 inches.

B. Place subbase in a manner to avoid segregation. Uncontrolled spreading shall not be permitted.

C. Do not place Type 3 material within 4 inches of the bottom of a pavement course.

3.3 COMPACTION

A. Where subbase courses must be moisture-conditioned before compaction, uniformly apply water to the surface. Prevent free water from appearing on the surface during or subsequent to compaction operations.

B. Compact all portions of each layer to a density not less than 95 percent of the maximum density.

C. Final tolerances for the top surface of the subbase course requires that the surface does not extend more than 1/4 inch above nor more than 1/4 inch below the specified grade at any location.

3.4 TRAFFIC ON SUBBASE

A. The movement of vehicular traffic over the final surface of the subbase may be permitted at locations designated by, and under such restrictions as ordered by the Engineer, provided such movements take place prior to the final finishing of this course to the specified tolerance. The movement of construction equipment on this course may be permitted, at locations designated by and under such restrictions as ordered by the Engineer at locations where permission is granted for such movement, the temporary surface of the course upon which the construction traffic is running, shall be placed and maintained for at least 2 inches above the final surface of this course. Just prior to paving, and after all construction traffic not required for the removal has ceased, remove the 2-inch protective layer, prepare the exposed surface of the course, and compact to the specified tolerance.

B. Should the subbase become mixed with the subgrade or any other material, through any cause whatsoever, remove such mixture and replace it with the specified subbase material.

3.5 FIELD QUALITY CONTROL

A. Notify the Engineer at least 1 working day in advance of all phases of subbase installation.

B. Comply with the requirements of this Section for in-place relative density testing.
   1. In-place relative density:
      a. Method: AASHTO T310, Nuclear Method.
      b. Number of Tests: 1 per specified interval.
   2. Compaction tests shall be provided for every 1000 square yard of subbase placement. A minimum of 3 for each lift is required.
   3. The Engineer may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions.
   4. Acceptance Criteria: The sole criterion for acceptability of in-place subbase shall be in situ dry density. Minimum dry density for all subbase shall be 95 percent of the maximum dry density. If a test fails to qualify, the fill shall be further compacted and re-tested. Subsequent test failures shall be followed by removal and replacement of the material.

END OF SECTION 321116

SECTION 321216 – ASPHALT PAVING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes provisions for asphalt concrete paving over prepared subbase.

B. This section includes provisions for replacing pavement removed during the course of the Work, or damaged resulting from Contractor's operations.

1.2 REFERENCES

A. The latest edition of the following standards, as referenced herein, shall be applicable:
   1. EDIT BELOW AS REQUIRED FOR PROJECT. REVISE FOR PROJECTS OUTSIDE OF NEW YORK STATE.
   2. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering".
   3. Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).
   4. American Society for Testing and Materials (ASTM).

1.3 SUBMITTALS

A. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements.

B. Field Test Reports: Submit results of field testing directly to the Engineer.

C. Request for placement of Top Course: If applicable, request Owner/Engineer approval for placement of Top Course outside of seasonal limitations noted herein. Include a copy of the Limited Warranty for approval.

1.4 SITE CONDITIONS

A. Temperature and Seasonal Limitations:
   1. Do not place asphalt plant mix on any wet surface or when surface temperature is less than specified in Table 404-3.01, Temperature and Seasonal Requirements in the latest edition of the NYSDOT Standard Specifications.
   2. Apply tack coats when ambient temperature is above 50 DegF (10 DegC) and when temperature has not been below 35 DegF (1 DegC) for 12 hours immediately prior to application. Do not apply when base is wet or contains an excess of moisture.
   3. Place Top Course between April 15 and October 31. Placing Top Course outside the limitations will require Owner/Engineer approval and approval of a limited warranty against defects in such work prior to implementation. Perform the warranty work in

accordance with Materials Procedure (MP) 402-01, Warranty Requirements for Asphalt Top Course. Unless specified elsewhere in this specification or contract documents, these seasonal limits do not apply for any other asphalt course placement.

B. Grade Control: Establish and maintain required lines and elevations.

C. In no instance shall the materials and thicknesses of pavement and subbase courses replaced be less than that removed, unless approved by the Engineer.

1.5 SEQUENCING AND SCHEDULING

A. Coordinate the placement of asphalt concrete pavement with the completion of underground work by other trades.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General: Asphalt concrete and all related items shall meet the requirements of NYSDOT Section 400.

B. No NYSDOT Quality Adjustment will be paid for under this contract.

C. Performance Graded Binder:
1. PG 64S-22, NYSDOT Specification 702-1 e.g., consult local DOT specifications.

D. Binder Course:
1. NYSDOT 404.258901 See NYSDOT Standard Specifications.

E. Top Course:
1. NYSDOT 404.128301 See NYSDOT Standard Specifications.

F. Tack Coat:
1. Emulsified asphalt, ASTM D977 NYSDOT Table 702-8.

G. Joint Adhesive:
1. Hot-applied modified asphalt product conforming to NYSDOT Specification 705.19.
2. The-joint adhesive materials shall be on the NYSDOT approved materials list.

PART 3 – EXECUTION

3.1 SURFACE PREPARATION

A. General: Remove loose material from compacted subbase surface immediately before commencing paving operations.

B. Proof-roll prepared subbase surface with a 10-ton static, steel-wheel roller to check for unstable areas and areas requiring additional compaction, witnessed by the Engineer at least 48 hours prior to scheduled paving operations.

C. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving.

D. Sawcut edges of existing pavement to achieve straight line transitions between old and new pavement. Make a second sawcut through the top course of existing pavement, 18 inches from the first cut to provide a staggered joint.

E. Tack Coat: Apply to contact surfaces of previously constructed asphalt or Portland cement concrete and surfaces abutting or projecting into asphalt concrete pavement. Distribute at rate of 0.03 to 0.07 gallons per square yard of surface. Tack coat shall be applied between each layer of the pavement section.
   1. Allow to dry until at proper condition to receive paving.

F. Joint Adhesive:
   1. Apply joint adhesive to all pavement edges in accordance with NYSDOT Section 418 Asphalt Pavement Joint Adhesive prior to placing the asphalt mixture in order to provide bonding with the newly laid pavement. The application of joint adhesive is for Top Course only.
   2. Apply the joint adhesive when surface temperature is 40 DEGF and rising. Use an applicator wand fitted with a sealing shoe to strike-off the adhesive. Strike-off the joint adhesive to provide a 1/4 inch to 3/8 inch thick band. The finished bands are to be approved by the Engineer.
      a. Wedge Joints:
         1) Apply the joint adhesive to the entire vertical face and the upper 2 inches of the wedge joint.
      b. Butt Joints:
         1) Apply the joint adhesive to the entire vertical face of the butt joint.
   3. The joint adhesive will be considered cured when construction and/or vehicular traffic does not track or pick up the material. Reapply joint adhesive to any areas damaged by construction and/or vehicular traffic prior to placing the adjacent asphalt pavement.

G. Exercise care in applying bituminous materials to avoid smearing of adjoining surfaces. Remove and clean damaged surfaces.

H. Do not commence pavement replacement operations until all buried work beneath pavement repair has been completed to the satisfaction of the Engineer.

I. Where trench dimensions preclude the use of proof rolling equipment, demonstrate the stability of the subgrade and subbase through other means, as acceptable to the Engineer.

3.2 PLACING AND COMPACTING MIX

A. General: Place and compact asphalt pavement courses in accordance with NYSDOT Section 404-3 unless otherwise specified.

B. Place inaccessible and small areas by hand and compact with hot hand tampers or vibrating plate compactors.

C. Chamfer edges of walks at 45-degree angle where walks do not abut curb.

D. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of asphalt concrete course. Clean contact surfaces and apply tack coat.

E. Place tack coat between successive courses if more than 48 hours have elapsed after placing the preceding course. Apply tack coat at a rate of 0.03 to 0.07 gallons per square yard of surface.

F. Remove and patch areas of any asphalt concrete course deemed unsatisfactory by the Engineer, at the Contractor's expense. Remove hardened or set asphalt by saw cutting.

G. Adhere to NYSDOT compaction requirements. This, however, shall not relieve the Contractor of his responsibility to provide a well densified pavement. It shall be the Contractor's obligation to recognize difficulties in compacting the mix, and to make appropriate corrections.

H. Roll and compact the asphalt concrete course until the finished surface is free from depressions, waves or other defects that would prevent proper drainage. The finished surface shall be uniform in texture and appearance.

I. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

J. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

K. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D979 or AASHTO T168.
   1. Reference maximum theoretical density will be determined by averaging results from 4 samples of asphalt-paving mixture delivered daily to site, prepared according to ASTM D2041, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D1188 or ASTM D2726.
      a. One core sample will be taken for every 1000 square yard (836 square meter) or less of installed pavement with no fewer than 3 cores taken.

L. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D2950 and correlated with ASTM D1188 or ASTM D2726.
   1. Replace and compact asphalt where core tests were taken.
   2. Remove and replace or install additional asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.3 FIELD QUALITY CONTROL

A. General: Test in-place asphalt concrete courses for compliance with requirements for thickness and surface smoothness. Repair or remove and replace unacceptable paving as directed by Engineer.

B. Thickness: In-place compacted thickness tested in accordance with ASTM D3549 will not be acceptable if exceeding following allowable variations:
   1. Base Course: Plus or minus 1/2 inch.
   2. Binder and Surface Course: Plus or minus 1/4 inch.
   3. Cumulative Thickness Tolerances: Plus or minus 1/4 inch for nominal cumulative thicknesses less than or equal to 4 inches. Plus or minus 1/2 inch for nominal cumulative thicknesses greater than 4 inches.

C. Surface Smoothness: Test finished surface of each asphalt concrete course for smoothness, using 10-foot straightedge applied parallel with and at right angles to centerline of paved area. Surfaces will not be acceptable if exceeding the following tolerances for smoothness:
   1. Base and Binder Course Surfaces: 1/4 inch.
   2. Wearing Course Surface: 3/16 inch.
   3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

D. Check surface areas at intervals as directed by Engineer.

E. Scuff Resistance: If, in the opinion of the Engineer, the pavement does not demonstrate reasonable resistance to deformation by punching loads and scuffing under horizontally applied shearing loads, after the pavement has cooled and hardened, the Engineer may require laboratory testing of cored pavement samples to determine the properties of the pavement; including aggregate gradation, asphalt content, air void ratio, density and any others deemed appropriate. If laboratory testing indicates that any parameters substantially deviate from the design mix tolerances specified by NYSDOT, replace the affected areas of pavement at no additional cost, and reimburse the Owner for all costs incurred in procurement and testing of cores.

END OF SECTION 321216

SECTION 321217 – CHIP SEAL PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Chip seal paving.

B. Related Sections include the following:
   1. Division 31 Section 312000 “Earth Moving” for aggregate subbase courses and non-woven geotextile.
   2. Division 32 Section 321216 “Asphalt Pavement” for hot-mix asphalt pavement.

1.3 SUBMITTALS

A. Product Data: For each product specified. Include technical data and tested physical and performance properties.

B. Qualification Data: For firms and persons specified in the “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and the Director’s Representative, and other information specified.

C. Material Test Reports: Indicate and interpret test results for compliance of materials with requirements indicated.

D. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

E. Material sample: For chip seal aggregate. Contractor shall supply (5) five separate chip seal aggregate stone source quarries for review and approval. Source quarries for chip seal aggregate shall represent varying stone color options.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Provide hot-mix asphalt pavement according to the materials, workmanship, and other applicable requirements of the New York State Department of Transportation (NYSDOT) Standard Specifications, Construction and Materials.

B. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
   1. Installer must have 10 years' experience with chip seal pavement and shall have at least 5 chip seal pavement installations of similar size and scope.

C. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.
   1. Firm shall be a registered and approved paving mix manufacturer with NYSDOT.

1.5 PREINSTALLATION CONFERENCE

A. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings" Review methods and procedures related to chip seal paving including, but not limited to, the following:
   1. Review and confirm the proposed mock-up location for approval by the Director's Representative.
   2. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture the emulsion.
   3. Review condition of substrate and preparatory work performed by other trades.
   4. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
   5. Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
   6. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
   7. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: The Contractor shall comply with NYSDOT Specification 402-3.01 Weather and Seasonal Limitations. Do not apply asphalt materials if substrate is wet or excessively damp or if the following conditions are not met:
   1. Shall not be applied on saturated subbase, wet pavement, or when standing water is present.
   2. The pavement surface temperature is below 60 deg F.
   3. The ambient temperature is below 50 deg F.
   4. Weather conditions would prevent the proper construction of the chip seal paving.

B. Seasonal Limitations:
   1. Chip seal shall be placed during the period from May 1st through September 7th.
   2. The Contractor may propose to place surface and binder course hot mix asphalt pavement outside of the seasonal and/or weather limitations by providing a warranty against defects in such work in accordance with NYSDOT Materials Procedure 402-01, Warranty Requirements.

PART 2 - PRODUCTS

2.1 CHIP SEAL AGGREGATE AND EMULSION – DELEGATED DESIGN

A. The Contractor shall ensure that the selected bituminous material is compatible with the selected aggregate. Contractor shall be responsible for testing the selected aggregate with the emulsion. The Contractor shall note that selection of the proper emulsion shall be a delegated design, provided by the Contractor as part of the submittal process.

B. Bituminous materials shall meet all applicable requirements of Section 702 of the NYSDOT Standard Specifications except as modified herein.

C. The bituminous material shall be polymer modified to increase the aggregate.

D. e retention. The bituminous material penetration value shall be between 80 and 150 according to AASHTO T 49-07 Penetration of Bituminous Materials.

E. Contractor shall supply (5) five separate chip seal aggregate stone source quarries for review and approval. Source quarries for chip seal aggregate shall represent varying stone color options, from dark gray to light gray color range.

F. Chip seal aggregates shall conform to the requirements of Section 703-02, Coarse Aggregates. The aggregate size shall be No. 1A and shall meet the requirements of Materials Method 410, 'Chip Seal Guidelines'.
   1. The Contractor's attention is directed to the fact that the aggregate color selection is of upmost importance for the historic restoration of the site.
   2. Final aggregate quarry source shall be per the selected Contractor provided sample. By submitting aggregate sample, the Contractor represents that the provided aggregate is compatible with the emulsion asphalt material.
   3. Aggregate shall be clean, double washed stone with no fines or deleterious material.

2.2 MATERIAL SAMPLING AND TESTING

A. Contractor testing for aggregate material: The Contractor shall retain the services of a material testing agency and shall submit the following tests to the Director's Representative:
   1. Obtain a minimum of three samples, according to ASTM D75, Standard Practices for Sampling Aggregates. Each sample must contain material from each face of the stockpile.
   2. Test samples in accordance with AASHTO T 11, Materials Finer than #200 Sieve in Mineral Aggregates by Washing, and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregates. Test results shall be based on the average of three tests.
   3. Test samples in accordance with Materials Method 28, Friction Aggregate Control and Test Procedures.
   4. Test samples to determine the aggregate's flakiness index as defined by Materials Method 410, Chip Seal Design Mix.
   5. Test samples to confirm designations as outlined in NYSDOT Standard Specifications Table 702-2 Physical Requirements (Testing); Table 702-3 Physical Requirements (Deleterious Materials), and Table 702-4 Size of Stone, Gravel and Slag.
   6. Test sample to confirm compatibility with asphalt emulsion.

7. The Director's Representative may elect to sample the aggregate stockpile to verify aggregate material testing and shall reject in-place material that does not meet testing requirements contained herein.

PART 3 - EXECUTION

3.1 ASPHATL PAVING INSTALLATION

A. See Section 32 12 16 "ASPHALT PAVING", for examination, surface preparation, hot mix asphalt placing, joints, compaction, installation tolerances, and field quality control.

3.2 EQUIPMENT

A. All equipment shall be maintained in satisfactory working conditions at all times.
   1. Sweepers:
      a. Self-propelled rotary power broom: shall be designed, equipped, maintained, and operated so the pavement surface can be swept clean.
      b. Self-propelled pick up broom or vacuum: shall be designed, equipped, maintained, and operated so that the pavement can be swept clean. Excess aggregate shall be contained in an onboard hopper and disposed of by the Contractor.
   2. Bituminous Material Distributor:
      a. The distributor shall be equipped, maintained, and operated so that bituminous material can be applied uniformly on variable widths up to 12 feet; and at controlled temperature and rates from 0.05 to 0.55 gallons per square yard. Prior to starting work, the distributor shall be calibrated for transverse and longitudinal application rate by ASTM D 2995, Standard Practice for Estimating Application Rate of Bituminous Distributors, or an equivalent method approved by the Director's Representative. The Contractor shall provide documentation certifying the calibration.
      b. The distributor shall uniformly apply the bituminous material at the specified rate with a maximum allowable variation of 0.02 gallons per square yard.
      c. The distributor equipment shall include accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with full circulation spray bars adjustable laterally and vertically. The distributor shall be equipped with a bituminous material sampling valve.
   3. Aggregate spreader:
      a. The aggregate spreader shall be a self-propelled unit capable of uniformly spreading the aggregate at the required rate on a minimum width of 6 inches wider than the width of the lane to be treated. Prior to starting work, the spreader shall be calibrated using ASTM D 5624, Standard Test Method for Determining the Transverse-Aggregate Spread Rate for Surface Treatment Applications. The Director's Representative will witness the equipment calibration or require the Contractor to provide documentation certifying the calibration.
   4. Pneumatic tire roller:
      a. Pneumatic tire rollers shall be self-propelled and have oscillating wheels with smooth tread tires and will have a minimum ground contact pressure of 80 psi. The

tire pressure for all wheels shall be uniform within ± 5 psi. The rollers shall be operated at a maximum speed of 5 mph.

3.3 SURFACE PREPARATION

A. Perform all surface preparations prior to applying chip seal.
   1. Thoroughly clean the entire area to be applied with chip seal paving and remove all dirt, oil, foreign materials, debris, and standing water.
   2. Protect manhole covers, water boxes, catch basins, and other utility structures with plastic, building felt, or other material approved by the Director's Representative. Cover protections shall be removed and replaced at the conclusion of each day.

B. Contractor shall allow asphalt base to cure for at least 2 months prior to chip seal installation.

3.4 CHIP SEAL

A. Application of bituminous material:
   1. Bituminous material shall be applied in a uniform, continuous spread over the section to be treated and within the temperature range recommended by the manufacturer. The Contractor shall document and report to the Director's Representative any field changes in application rates from the mix design submittal.
   2. Where longitudinal joints are to occur, the application of bituminous material from the initial pass shall extend 6 inches beyond the area to be covered with aggregate. Subsequent passes of the bituminous spreader shall overlap the exposed bituminous material and the edge of the initial aggregate pass.
   3. Uncovered bituminous material shall not be exposed to traffic.
   4. All bituminous material shall be covered with aggregate before opening to traffic. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. If any skipped areas or deficiencies occur, the operation shall be immediately stopped. The bituminous material shall not be applied more than 200 feet in advance of the self-propelled aggregate spreader. The distributor, when not spreading, shall be parked so that the spray bar or mechanism will not drip bituminous material on the surface of the roadway.

B. Application of cover aggregate:
   1. Immediately following the application of the bituminous material, cover aggregate shall be spread at the rate established by the Contractor in the mix design. The Contractor shall document and report to the Director's Representative any field changes in application rates from the mix design submittal. Spreading shall be accomplished in such a manner that construction equipment or other vehicles shall not drive on the uncovered and newly applied bituminous material. Any free bituminous material on the surface caused by a deficient amount of cover aggregate shall be covered by broadcasting additional aggregate over the deficient area.
   2. Longitudinal joints shall be parallel to the centerline. Ensure that longitudinal joints will correspond with the edges of the proposed traffic lane. Where any construction joint occurs, the edges shall be broomed back and blended so there are no gaps and the elevations are the same, and free from ridges and depressions.
   3. Initial rolling of cover aggregate shall occur within 5 minutes after the application of bituminous material. Cover aggregate shall receive a minimum of three roller passes

within 30 minutes of bituminous material application. Use the table below to determine the minimum number of rollers required:

Overlay Width (Feet)	Number of Rollers (Minimum)
≤ 6	1
$> 6 \leq 9$	2
$> 9 \leq 12$	3
> 12	4

C. Sweeping:

1. Sweep loose stone from the newly treated surface. Additional sweeping shall be performed as directed by the Director's Representative during a 5-day period following placement of the chip seal.

3.5 REPAIRS, CLEAN-UP, AND PROTECTION

A. Remove and replace paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections of adequate size to blend repaired work into existing. Confirm replacement section size and location with the Director's Representative for approval.

B. Protect paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321217

SECTION 321560 – BOUND AGGREGATE STONE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes:

1. Bound aggregate stone surfacing over frost-resistant drainage mortar installed on drainage mat on concrete substrate.

1.2 PRE-INSTALLATION MEETING

A. Pre-installation Conference: Conduct conference at Project site as arranged by the Director's Representative.

B. Required to attend:

1. Director's Representative
2. General Contractor
3. Installing Contractor
4. Surfacing system manufacturer representative
5. Landscape Architect

1.3 DEFINITIONS

A. Exposure Condition, Moderate: Exposure to a climate where the paving will not be in a saturated condition when exposed to freezing and will not be exposed to de-icing agents or other aggressive chemicals.

B. Stabilized Aggregate: A paving system comprised of three components: aggregate, and 2 component epoxyresin system binder that provides a strong, pervious, yet flexible paving.

C. Subbase: A layer in a paving system between the subgrade and the base course, or between the subgrade and a flexible pervious paving.

1.4 ACTION SUBMITTALS

A. Product Data: for each product specified.

B. Samples for Initial Selection: Custom blends of aggregate colors to achieve a mix of light grey, dark grey, and black aggregates for selection by Landscape Architect.

1. Provide four proposed blends for initial review.

2. Provide four revised blends for final selection review.
3. Provide sieve analysis.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data

1. Manufacturer Qualifications
2. Installer Qualifications

B. Certification of Installer's acceptance by the Manufacturer.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A manufacturer with a minimum of five years of successful bound surfacing system (both aggregate and binding agent). Product Manufacturer shall be ISO 9001 certified and maintain a quality assurance program.

B. Installer Qualifications:

1. Installer shall have the experience of at least ten (10) acceptable installations of complex paving pattern installation in the United States within the past five (5) years.

2. Installer shall be trained in the Drainage Mortar System products by the manufacturer's representative.

3. Stabilized Aggregate Paving installer shall employ no less than two Manufacturer-certified Stabilized Aggregate technicians on staff who directly oversee or perform the installations during all stabilized aggregate placement, unless otherwise specified.

C. Mockups:

1. Preliminary Mockup for Color Verification: Construct pre-mockup sample fields 36 inch by 48 inch of the full-depth bonded aggregate stone surfacing system demonstrating the range of color surface aggregate.

    a. Provide four preliminary mockups for color and texture selection by the Landscape Architect.
    b. Locate approved preliminary mockup on site outside area of construction as directed by the Director's Representative. Retained approved preliminary mockup sample field for comparison to final mockup.

2. Final Mockup: Provide a 15 foot by 15 foot full depth installation of bonded aggregate stone using color selection from preliminary mockup.

    a. Schedule and pay for surfacing system manufacturer representative t be on site full time during installation.

b. Locate mock where directed by the Director's Representative.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver aggregates deliver in sealed bags clearly labeled as to manufacturer and material color.

B. Store aggregate protected from moisture and weather.

C. Store liquids in tightly closed containers protected from excessive heat or freezing.

D. Store Romex products according to Manufacturer's written instructions.

1. Store Rompox Profi-Decko® in tightly sealed containers where there is good ventilation. Protect from frost, heat, and direct sunlight.
2. Store Romex Trass Bed Compound® locked up in a well-ventilated space. Keep container tightly closed. Protect from humidity and keep away from water.

1.8 PROJECT CONDITIONS

A. Install bound crushed stone surfacing when temperatures are between 40°F and 85°F.

B. Do not allow walking traffic for 24 hours after completion. Allow 6 days for paving to be fully load bearing.

PART 2 - PRODUCTS

2.1 GENERAL

A. A three-part system consisting of mix of rounded aggregate and a two-component Epoxy Resin on an approved clean compacted aggregate base course to form a highly water permeable.

2.2 BOUND AGGREGATE STONE SURFACING

A. Basis of Design: Rompox Profi-Deko® as supplied by Romex.

B. Contact Information,
Romex, US
55 Greenwood Ave., Bethel, CT 06801
TEL 866.766.3963
henri@romex.us "Romex Support" info@romex.us
Telephone: (866) 766-3963

C. Stone: 1/16 inch to ½ inch aggregate to match existing and approved by the Landscape Architect.

1. No fines.

D. Technical Data:

1. Compressive Strength: 2,016 psi (13.9 N/mm^3) Building site value – DIN 18555 part 3.
2. Bending Tensile Strength: 696 psi (4.8 N/mm^3) Building site value – DIN 18555 part 3.
3. Hard Mortar Raw Density: 0.91 oz/in^3 (1.58 kg/dm^3) Building site value – DIN 18555 part 3.

2.3 BASE COURSE FOR STONE SURFACING

A. Basis of Design: Rompox Trass-Bed® as supplied by Romex, a ready to use mortar containing Portland cement.

B. Contact Information,
Romex, US
55 Greenwood Ave., Bethel, CT 06801
TEL 866.766.3963
henri@romex.us "Romex Support" info@romex.us
Telephone: (866) 766-3963

C. Technical Data

1. Compressive Strength: 2,175-3626 psi (>15-25 N/mm3) after 28 days (dependent on filler material.
2. Water Permeability Coeffcient: ≥20.1 iph (14.2x10^3 m/sec).
3. Low chromate

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. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BASE COURSE

A. Comply with the manufacturer’s written instructions.

B. Preparation

1. The subsurface needs to be made load bearing, firm and water permeable.
2. Any water that gathers needs to be drained with corresponding drainage measures. In case of any watertight outdoor areas and levels where water flows and partial puddles form, it is recommended installing a suitable capillary-breaking drainage mat.

3. Protect building surfaces, curbs, walls, pavers, utility castings and other adjacent construction and finishes from damage during installation.

C. Mixing – follow manufacturer's written instructions.

1. Use cool, clean water.
2. Add water until the mortar mixture is slightly shiny and can be rolled into a firm ball.
3. Use a pug mill mixer or gravity mixer.

D. Application – follow manufacturer's written instructions

1. Thickness of bed as shown.
2. Lay mixed bedding mortar loosely.

3.3 AGGREGATE TOP COURSE

A. Comply with the manufacturer's written instructions.

B. Preparation

1. Confirm that all aggregate for use with Romex Profi-Deko is clean and completely dry. Any dampness can lead to loss of strength. For this process use either method described below:

   a. Pour gravel or grit into a concrete mixer, add enough clean water and mix well for at least 1 minute. After completing the mixing process carefully pour the cloudy water out of the mixer. Repeat the process until the emptied water is almost clear and the grit/gravel is clean. Spread the washed gravel in a thin layer on a fleece or mat and allow to dry completely (ideally under direct sunlight).
   b. Fill a clean mortar trough with clean water, pour the grit/gravel into a metal basket or similar, dip the metal basket into the mortar trough and move it up and own until the gravel is cleaned. Then dry as above.

C. Mixing – follow manufacturer's written instructions.

1. Use mixing ration in manufacturer's consumption table.
2. Use pug mill mixer or free fall mixer.

D. Application– follow manufacturer's written instructions.

1. Pour the ready to use mix onto the prepared surface. If necessary, disperse it with a shovel and draw off on the same level with a level rod.
2. Compact the mixture using a light vibratory plate or smoothing trowel and then smooth off the surface.
3. Use precautionary measures to avoid any impurities by binding agent and footprints on the stone surface.
4. Protect for the next 12 -24 hours.

a. Do not lay rain protection layer directly onto the paved surface. This ensures sufficient air circulation.

5. Immediately after the surface has hardened paint Rompox Profi-Deko over the stone surface undiluted using a paintbrush or fur roller as a sealant. (This process is repeated on average every 3 years.)

3.4 END OF SECTION 024119

SECTION 321400 - UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Salvaged and cleaned Bluestone Pavers, Stepping Stones, and Stair Treads set in mortar setting beds.
2. Supplementary Bluestone Pavers, Stepping Stones, and Stair Treads as required.
3. Cobble Gutter
4. Stone Cheek Wall
5. Manhole Cover.

B. Related Requirements:

1. Section 033000 – “Cast-In-Place Concrete” for stair foundations

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:

1. New bluestone
2. Cobble Stones
3. Mortar materials.
4. Thinset materials.
5. Jointing materials
6. Setting Bed material

C. Samples for Initial Selection:

1. Bluestone Pavers to match existing.
2. Bluestone stair tread and Stone Cheek Wall for exposed face finish and color. 4”x4”x4”.
3. Stone for Cobble Gutter
4. Joint materials 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**:**

1. Full-size units of bluestone pavers showing full range of size, finish and color variation.
2. Joint materials.

E. Terrace Garden Paving Salvage Plan: Use photos and drawings to provide layout of Terrace Garden Pavers, numbering each paver in the plan.

F. Stone Cleaning Plan: Provide a written description of the products and methods for cleaning the salvaged stone material.

1.4 ATTIC STOCK

A. Contractor will provide attic stock equivalent to 3 percent of the total of existing and new bluestone plus 10 percent of the new 3-inch bluestone.

1.5 INFORMATIONAL SUBMITTALS

A. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

B. 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.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer shall have the experience of at least ten (10) acceptable installations of complex paving pattern installation in the United States within the past five (5) years.
2. Installer shall be trained in the Drainage Mortar System products by the manufacturer's representative.

B. Drainage Mortar System Manufacturer Qualifications

1. Product Manufacturer shall be ISO 9001 certified and maintain a quality assurance program.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, mix of new and salvaged existing stones and to set quality standards for materials and execution.

1. Minimum Mock-up size for Paving: 96 inches (2400 mm) long by 48 inches (1200) wide.
2. Minimum Mock-up for Cobble Gutter: full width by 96 inches long
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store Drainage Mortar system components off the ground and avoid excessive heat, rain, or freezing temperatures until ready for use.

C. All Drainage Mortar system components must be delivered in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers. Damaged material must be documented, reported to manufacturer and removed from site.

D. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

E. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

F. Salvaged bluestone pavers shall be palletized and wrapped and stored in a manner to prevent damage until re-installation.

G. Store liquids in tightly closed containers protected from freezing.

1.8 FIELD CONDITIONS

A. Follow manufacturer's written instructions for field conditions necessary for setting bed, thin set and jointing materials.

B. Cold-Weather Protection: Do not use frozen materials or materials mixed with 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.

C. Limitations for Drainage Mortar System.

1. Site Conditions: The foundation needs to be prepared according to the expected traffic loads. Superstructure and substructure must be water permeable. Future loads must not cause the surface to settle or loosen stones. Regulations and leaflets regarding construction of paved stone surfaces should be heeded. Future loads must not cause the surface to settle or loosen stones.
2. When ambient temperature is below 5°C (40°F) or expected to fall below 5°C (40°F) within the next 24 hours, or when ambient temperature is above 25°C (77°F) or expected to rise above 25°C (77°F), do not mix or place mortar.
3. Product should not be applied in rain.
4. Protection: Precautions should be taken to protect surrounding surfaces that are not to receive the product.
5. Heating mixing water or same or use of anti-freeze compounds is prohibited.

D. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6. Provide artificial shade and windbreaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F (38 deg C) and higher.

    a. When ambient temperature exceeds 100 deg F (38 deg C), or when wind velocity exceeds 8 mph (13 km/h) and ambient temperature exceeds 90 deg F (32 deg C), set pavers within 1 minute of spreading setting-bed mortar.

1.9 WARRANTY FOR DRAINAGE MORTAR SYSTEM

A. Provide a written warranty from the manufacturer against defects of materials for a period of 10 years. This begins at the date of substantial completion of the project.

B. Provide an onsite mockup to ensure that the products are used in accordance with this specification and qualify for the 10-year system warranty.

C. Provide a written warranty from the manufacturer against defects of system for a period of 10 years, this begins at the date of substantial completion of the project.

PART 2 - PRODUCTS

2.1 SALVAGED BLUESTONE: PAVERS, STEP RAMP, AND STEPS

A. Salvage bluestone pavers and steps: All bluestone pavers around the Bedford House will be salvaged. All of the large stone treads from outside the herb garden will be salvaged as indicated on the drawings.

B. Each existing paving stone in the Terrace Garden must be clearly marked per the approved Paving Salvage Plan for replacement in the exact same location in the finished Work.

1. Markings must be legible and able to remain until the resetting has been completed and approved by the Director’s Representative.
2. Markings must be completely removable by means that will not damage the paving stones.
3. Existing unbroken pavers or treads shall be carefully removed, cleaned, stored, and reset.
4. Careful removal is required so that the stone is not broken. Any stone that is broken during those operations shall be replaced at no cost to the Owner.

2.2 NEW BLUESTONE: PAVERS, STEPPING STONES, AND STEPS

A. Source Limitations: Obtain each type of unit paver from a single source with resources to provide materials and products of consistent quality in appearance and physical properties to match existing cleaned salvaged stone,

B. Bluestone Rectangular paving slabs and stair treads in a variety of sizes made from quartz-based stone complying with ASTM C616/C616M.

1. Stone Abrasion Resistance: Minimum value of 8, based on testing according to ASTM C241/C241M or ASTM C1353.
2. Finish on visible faces: Natural cleft. To match cleaned salvaged bluestone from project.
3. Finish on hidden faces: sawn.
4. Match Cleaned salvaged bluestone for color, finish, and other stone characteristics relating to aesthetic effects.
5. Thickness: Not less than 2 inches (51 mm), except as indicated on the drawings that the pavement will be subject to vehicular traffic where the thickness should be not less than 4 inches (100 mm).
6. Face Size: As indicated.

2.3 STONE FOR COBBLE GUTTER

A. Provide locally quarried stone

1. 3 inches to 5 inches, River Jack stone grey and beige mix.

2.4 MANHOLE COVERS

A. Galvanized steel, recessed tray, manhole cover for paver area.

1. Dimensions: 24 inches by 24 inches.

B. Basis of design: Provide the following or Landscape Architect approved equal:

1. WunderCover Manhole Cover
2. Contact Information:
   3432 Denmark Avenue, Ste 214
   Eagan, MN 55123
   Phone 775-400-2883
   Email: info@wundercovers.com

2.5 DRAINAGE MORTAR SYSTEM

A. Mortar compound, thinset product, and jointing material must be obtained from same manufacturer.

B. See details for pavers and cobble gutter for profiles.

C. Basis of design: Provide the following or Landscape Architect approved equal.

1. Drainage Mortar Romex – Trass Bed Compound,
2. Paver Thinset: Romex - Adhesion Elutriant,
3. Jointing Sand: Romex - Rompox EcoFine,
4. Contact Information: Romex Northeast, USA

55 Greenwood Ave. Bethel, CT 06801
Phone: 866.766.3963
Henri Hillmann- henri@romex.us

D. System must be tested based on ASTM C67-C666 – Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing using the most extreme scenario. The 28-day results must certify that there is no visible decay, no adhesive issues between paver units and mortar material, and no visible decay of mortar between the paving units.

E. Follow Manufacturer's instructions.

F. Drainage Mortar Compound: Drainage Trass Mortar Compound must meet the following specifications:

Application time	Approximately 1 hour at 20 degrees C / 68 degrees F application temperature
Application temperature	5-25 degrees C / 41-77 degrees F; do not lay onto frozen ground
Compressive strength	Greater than 15-25 N/mm^2 / 2,175-3,626 psi after 28 days (dependent on filler material)
Water permeability coefficient	Equal to or greater than 14.2 x 10-5 m/sec / 20.1 iph (dependent on filler material)
Low chromate	Yes

G. Thinset product: Paver thinset (Romex Adhesion Elutriant) must be from the same manufacturer as the mortar compound and meet the following specifications:

Application time	Approximately 2 hours at 20 degrees C / 68 degrees F application temperature
Dry Density	1.5 kg/dm^3 / 0.87 oz/in^3
Low chromate	Yes

H. Jointing Sand: Jointing sand (Romex Rompox EcoFine) must be from the same manufacturer as the mortar compound and meet the following specifications:

1. Applicable to joint widths 3-5 mm, and joint depths from 30 mm for closely laid paving stones
2. Solvent free copolymer resin based on renewable resources.
3. Compressive strength 8.5 N/mm3 / 1,233 psi Building site value (DIN 18555 part 3)
4. Resistant to frost and road salt
5. Ready mixed
6. Can be elutrified without loss of quality
7. Does not seal the joint / water permeable
8. Can be washed with a pressure washer

9. Color: to be selected by the Landscape Architect from the full line of manufacturer's options.

I. Water: Potable.

2.6 MORTAR SETTING-BED MATERIALS FOR STEPS AND CHEEK WALL

A. Portland Cement: ASTM C150/C150M, Type I or Type II.

B. Hydrated Lime: ASTM C207, Type S.

C. Sand: ASTM C144.

D. Water: Potable.

2.7 MORTAR MIXES FOR STEPS AND CHEEK WALL

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimal performance characteristics. Discard mortars if they have reached their initial set before being used.

B. Mortar-Bed Bond Coat: Mix neat cement and water to a creamy consistency.

C. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C270, Proportion Specification.

D. Color: From mortar manufacturer's standard range as selected by the Landscape Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, stair treads, stepping stones, and cobble gutter with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Mark out area from which bluestone pavers are to be chosen for salvage, cleaning and reuse.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Removal of existing bluestone pavers.

1. Remove bluestone pavers from the agreed upon existing pavement area following the approved Terrace Garden Paving Salvage Plan.
2. Salvage all bluestone pavers that are not broken or severely chipped for reuse.

    a. The Director's Representative will be the final arbiter of whether or not the stone is to be salvaged or not.

3. Clean bluestone pavers on all sides to original surface according to the approved Stone Cleaning Plan, palletize, and protect from damage or soiling.
4. Existing bluestone that is broken but useable as is or after cutting may be used outside of the Terrace Garden area.
    a. Any stone that is cut on site for paving must have the edges worked to match existing to the satisfaction of the Director's Representative.
5. Any stone that is whole but is broken during the salvage process must be replaced at no additional cost to NYS.
6. Dispose legally of all bluestone that has been deemed by the Director's Representative as not appropriate to be salvaged for reuse.

B. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.

C. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

3.3 BLUESTONE INSTALLATION, GENERAL

A. Do not use salvaged bluestone from the site that has not been approved by the Director's Representative.

B. Do not use salvaged bluestone from the site that has not been cleaned to the satisfaction of the Director's Representative.

C. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

D. Mix cleaned, salvaged bluestone from the site with new replacement pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

E. 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.

F. Joint Pattern: Match existing unit paver joint pattern and as indicated on the drawings.

G. Tolerances: Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) or 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.

3.4 DRAINAGE MORTAR SETTING-BED APPLICATIONS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar bed; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

C. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.

D. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform to back of each paver with a flat trowel per manufacturer's written instructions..

E. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

F. Spaced Joint Widths: as indicated.

G. Joints must be free of debris before the application of jointing sand.

H. Fill joints with jointing sand as per manufacturer's instructions.

3.5 MORTAR SETTING-BED APPLICATIONS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed 1/16-inch (1.6-mm) thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.

C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

D. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.

E. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform 1/16-inch- (1.5-mm-) thick bond coat to mortar bed or to back of each paver with a flat trowel.

F. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single

operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

G. Spaced Joint Widths: Provide 1/2-inch to 1.5 inches joints.

3.6 DRAINAGE

A. After 30 days, flood area with water and check for drainage and low spots. In areas where water ponds occur deeper than ½ inch, remove all bluestone necessary to adjust leveling course and reinstall bluestone pavers as indicated above.

3.7 REPAIRING, POINTING, 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.

B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with mortar. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

C. Cleaning: Remove excess mortar from exposed paver surfaces; wash and scrub clean.

END OF SECTION 321400

SECTION 321500 – CRUSHED STONE SURFACING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the placement of crushed stone pavement.

B. Place crushed stone pavement in conformance with the lines, grades, thicknesses and typical sections as shown or detailed on the Drawings.

1.2 REFERENCES

A. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering."

B. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."

C. "American Society for Testing and Materials (ASTM)."

1.3 SUBMITTALS

A. Samples:
1. The Contractor shall furnish earth materials to the testing laboratory for analysis and report, as directed by the Engineer, or as outlined in the specifications.

B. Test Reports:
1. The testing laboratory shall submit written reports of all tests, investigations, findings, and recommendations to the Contractor and the Engineer.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Subbase Course: Sound, durable blast furnace slag, stone, sand, gravel or blends of these materials, well-graded from coarse to fine and free from organic or other deleterious materials, conforming to the requirements of NYSDOT Section 304 and meeting the following gradation requirements (NYSDOT Type 2):

SIEVE	PERCENT PASSING
2"	100
1/4”	25 – 65
No. 40	5 – 40
No. 200	0 – 10

1. Magnesium Sulfate soundness loss after 4 cycles shall be less than 20 percent.
2. Plasticity Index of material passing No. 40 sieve shall not exceed 5.0.
3. Not more than 30 percent, by weight, of the particles retained on a 1/2 inch sieve shall consist of flat or elongated particles. A flat or elongated particle is defined as one which has its greatest dimension more than 3 times its least dimension.

B. It shall be the Contractor's responsibility to provide a material which meets this specification and is within his capabilities to fine grade to the required tolerances. Should the subbase course become unstable at any time prior to the placement of the overlying course due to the gradation of the material furnished, the Contractor shall, at his own expense, correct the unstable condition to the satisfaction of the Engineer.

C. All material shall meet the specified gradation prior to placement. All processing shall be completed at the source.

PART 3 – EXECUTION

3.1 PREPARATION

A. Establish required lines, levels, contours, and datum.

B. Maintain benchmarks and other elevation control points. Re-establish, if disturbed or destroyed at no additional cost to the Owner.

C. Place subbase only after subgrade has been proof-rolled and approved by the Engineer. Unstable or weak subgrade materials shall be replaced with suitable material at the Contractor's expense.

3.2 PLACING

A. Place soil stabilization fabric in accordance with Section "Stabilization Fabric," if required by the Drawings or otherwise specified.

B. All subbase material shall be placed in uniform horizontal layers with a maximum compacted thickness of 12 inches.

C. Place the subbase in a manner to avoid segregation. Uncontrolled spreading shall not be permitted.

3.3 COMPACTION

A. Where subbase courses must be moisture-conditioned before compaction, uniformly apply water to the surface. Prevent free water from appearing on the surface during, or subsequent to, compaction operations.

B. All portions of each layer shall be compacted to a density not less than 100 percent of the maximum density.

C. After compaction, the top surface of the subbase course shall not extend more than 1/4 inch above nor more than 1/4 inch below the specified grade at any location.

3.4 TRAFFIC ON SUBBASE

A. The movement of highway traffic over the final surface of the subbase may be permitted at locations designated by, and under such restrictions as ordered by the Engineer, provided such movements take place prior to the final finishing of this course to the specified tolerance. The movement of construction equipment on this course may be permitted, at locations designated by and under such restrictions, as ordered by the Engineer. At locations where permission is granted for such movement, the temporary surface of the course, upon which the construction traffic is running, shall be placed and maintained at least 2 inches above the final surface of the course. Just prior to paving and after all construction traffic, not required for the removal, has ceased, the 2 inch protective layer shall be removed, and the exposed surface of the course prepared and compacted to the specified tolerance.

B. Should the subbase become mixed with the subgrade or any other material, through any cause whatsoever, the Contractor shall, at his expense, remove such mixture and replace it with the appropriate subbase material.

3.5 FIELD QUALITY CONTROL

A. Notify the Engineer at least one (1) working day in advance of all phases of filling and backfilling operations.

B. Compaction testing shall be performed to ascertain the compacted density of the fill and backfill materials in accordance with Section "Quality Requirements."

C. Compaction tests shall be provided for every 250 cubic yards of fill for each lift.

D. The Engineer may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions, at the Contractor's expense.

E. Acceptance Criteria: The sole criterion for acceptability of in-place subbase shall be in situ dry density. Minimum dry density for all subbase shall be 100 percent of the maximum dry density. If a test fails to qualify, the fill shall be further compacted and re-tested. Subsequent test failures shall be followed by removal and replacement of the material.

END OF SECTION 321500

SECTION 321613.53 – GRANITE CURBS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the installation of Granite Curbs as shown on the Plans.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Granite Curbs, General: The stone shall be sound and durable, free from seams or cracks which impair its structural integrity and of a smooth splitting and machining character. Sample shall be submitted prior to purchase for approval.

B. Natural stone split face granite curb shall comply with the requirements of New York State Department of Transportation (NYSDOT) Section 609-3 and Section 714-01 of the NYSDOT Standard Specifications. Curbs shall have sawed back and top.

C. Granite Curbs, Dimensional Requirements: Curbs shall be cut to the shape and size shown on the Drawings, and to the dimensions for tangent sections as detailed. See details for specific dimensional requirements.

1. For curved, sloped granite curb, sections shall be cut to the curve required with end cuts on radial lines.
2. Supply straight and radius transition sections as shown on the drawings. Use of tangent sections to form radii is not allowed.

D. Granite Curbs, Finish Requirements: Curbs shall be finished as indicated on the Drawings, and as follows:

1. Top surfaces shall be finished to approximately true planes. When sawed, hammered or thermal finishes are applied, no projection or depression shall be greater than 1/8 inch (3 mm). Saw marks normal to the sawing process will be permitted if within the 1/8 inch (3 mm) tolerance.
2. Top front arris lines of curb shall be straight and true with no variations greater than 1/8 inch (3 mm) measured from a two-foot straightedge places along the arris line.
3. Back arris lines and front arris lines of curb shall be straight and true with no variations from a straight line greater than 1/4 inch (6.3 mm) measured in the same manner as previously described.
4. Exposed arris lines at joints of curb shall not project beyond the plane of the split face and shall not fall under the plane of a split face more than 1/4 inch (6.3 mm).
5. Back surfaces of curb shall have no projection or depression which exceeds a batter of 1 inch (25 mm) in 3 inches (75 mm) for a distance of 4 inches (100 mm) from the top.
6. Front exposed faces of straight curbs, when split, shall have no projection greater than 3/4 inch (19 mm) or depression greater than 1/2 inch (12.5 mm) measured from the vertical plane passing through the arris line at the top of the split face. For radius curb units the exposed faces

when split shall have no projection greater than 1 inch (25 mm). Front faces below grade shall have no projection or depression greater than 1/4 inch (6.3 mm) measured in the same manner.

7. Ends of curbs shall be approximately square with the planes of the exposed curb faces and shall be finished so that when curb sections are set, no space greater than 3/4 inch (19 mm) shall show in the joints for the full length of the exposed joint. Ends of curb shall be sawed at locations as indicated on the Drawings.
8. Drill holes will not be permitted in exposed curb surfaces.

E. Cement Mortar for Joints Between Curb and Rigid Pavement (Concrete): Cement mortar for filling granite curb joints shall be proportioned, by volume per cubic yard (per m3) in accordance with ASTM C 270, and as follows:

1. One (1) part Portland cement conforming to ASTM C150, Type II.
2. One (1) part mortar sand, conforming to Section 703-03 of NYSDOT Standard Specifications.
3. 70 pounds (32 kg) water proofing compound compatible with cement.
4. Mix cement mortar with water to produce mixture which is stiff as practicable and of such consistency that mortar will require rodding when placed in joints.
5. The grout shall extend from the bottom to the top of the pavement.

F. Dry Concrete: One (1) part Portland cement mix with six parts DOT No. 1A coarse aggregate dry mix.

G. Concrete: Ready-mix concrete conforming to ASTM C94 and this specification, will be approved if obtained from an established contractor. All concrete shall have a minimum cement factor of 6-1/2 bags per .82 cubic yards (0.75 cubic meters) of concrete, a maximum aggregate size of 1 inch (25 mm) and shall contain an air-entraining admixture to 5 percent plus or minus 1 percent by volume of total mixture.

1. Normal Portland Cement: Standard brand ASTM C-150, Type 1.
2. Sand: Shall be clean, sharp, natural sand, conforming to ASTM C-33-67. Material finer than 75 mm (#200) sieve shall not exceed 3 percent.
3. Aggregate: Shall be clean, strong, crushed limestone or natural washed gravel conforming to NYSDOT #1 as follows:

SIEVE SIZE DESIGNATION	PERCENT PASSING BY WEIGHT
1"	100
1/2"	90 – 100
1/4"	0 – 15

4. Water: Water for concrete shall comply with U.S. Department of Health Standards for drinking water.

PART 3 – EXECUTION

3.1 GENERAL:

A. Excavate a sufficiently wide trench, to permit thorough vibratory compaction of the subgrade and subbase materials, and to the required depth as indicated on the Drawings so as to permit the

installation of the curbing. The trench bottom and aggregate subbase material shall be thoroughly compacted in accordance with the requirements of Section "Subbase Courses."

B. The granite curb shall be set true to line and grade, as indicated on the Drawings, on a foundation of one cubic foot of dry concrete for each linear foot of curb installed. Provide firm and uniform bearing. Backfill with concrete continuously for the entire curb length to the size indicated on the drawings. Allow 3 days to cure before further backfilling. Care shall be exercised in backfilling to ensure against damaging or disturbing the curb.

C. Granite curbs with and without sawed ends, not on structure, shall be butted together with no mortar between the joints

D. Maintain curbs clean, aligned and protected from damaged until completion of Contract.

E. Repairs and Protection: Repair or replace broken or defective curbing as directed by the Engineer. Sweep clean curbing, and wash free of stains, discolorations, dirt and other foreign materials just prior to Substantial Completion inspection and to the satisfaction of the Engineer.

END OF SECTION 321613.53

SECTION 321630 – CONCRETE SIDEWALKS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the installation of concrete sidewalk as shown on the Drawings, or as specified herein.

B. The materials and methods specified herein are directly intended for placement of "new" concrete sidewalk. Where existing sidewalk is removed and replaced during construction, modifications to these specifications to match existing conditions shall be made as directed by the Engineer.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable.
      a. Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering..
      b. American Society of Testing and Materials (ASTM).
      c. American Concrete Institute (ACI).

B. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of materials with the specifications, if at any time during the Work, materials appear unsuitable in the opinion of the Engineer.

1.3 SUBMITTALS

A. Concrete:
   1. The Contractor shall furnish the name and location of the concrete supplier.
   2. Submit the design mix for each class of concrete prior to use in the Work.

B. Product Data:
   1. Submit manufacturer's catalog cuts, specifications, and installation instructions.

C. Test Results:
   1. The testing laboratory shall submit written reports of all tests, investigations, and recommendations to the Contractor and the Engineer.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Concrete:
   1. All cast-in-place concrete shall be ready mixed concrete meeting the following criteria:
      a. 28-day compressive strength-5000 psi
      b. Air entrainment-4% to 8%
      c. Slump-2" to 4"

B. Premoulded Expansion Joint Filler:
   1. Concrete curbing shall be provided with a 1/2 inch premoulded expansion joint filler conforming to ASTM D1751.
   2. The premoulded expansion joint filler shall be "pre-cut" to match the concrete sidewalk cross-sectioned dimensions as detailed on the Drawings.

C. Fabric Reinforcement:
   1. Flat sheets of 6 x 6 - W 2.9 x W 2.9, ASTM A1064, welded wire reinforcement.

D. Sealants:
   1. Joint Sealers: ASTM C920.

E. Forms:
   1. Sidewalk forms shall be of wood or steel, straight of sufficient strength to resist springing during depositing and consolidating concrete, and of a height equal to the full depth of the finished sidewalk.
   2. Wood forms shall be surfaced plank, 2-inch nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 10 feet, with a minimum of three stakes per form, at maximum spacing of 4 feet. Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Radius bends may be formed with 3/4-inch boards, laminated to the required thickness.
   3. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Form ends shall be interlocked and self- aligning. Forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Forms shall have a nominal length of 10 feet, with a minimum of two welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips, designed for use with steel forms.

PART 3 – EXECUTION

3.1 INSPECTION

A. The Contractor shall notify the Engineer 24 hours before placing concrete in order to give the Engineer an opportunity to inspect the formwork, reinforcing and related items prior to placement of the concrete.

B. Delivery tickets shall show the amount of cement, brand, and amount of all admixtures, in addition to information required by ASTM C94, Section 14. Water added on the job shall be approved and the amount noted on the delivery ticket and initialed by the Contractor.

3.2 SUBBASE PREPARATION

A. Concrete sidewalk shall be constructed on a compacted granular subbase as shown on the Drawings.

B. The completed subbase shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

C. The subbase shall be maintained in a smooth, compacted condition in conformity with the required section and established grade, until the concrete is placed.

D. The subbase shall be in a moist condition when concrete is placed.

E. The subbase shall be prepared and protected so as to produce a subbase free from frost when the concrete is deposited.

3.3 FORMWORK

A. Earth cuts may not be used as forms for vertical surfaces.

B. All forms shall be built mortar tight and of materials sufficient in strength to hold concrete without bulging between supports. Forms shall be maintained to eliminate the formation of joints due to shrinkage of the forms. Concrete, misshapen by bulges or deformations caused by inadequate forms, shall be removed or corrected as ordered by the Engineer. All replacements or corrections shall be made at the Contractor's expense.

C. All surfaces of wooden forms that will be in contact with exposed concrete shall be thoroughly treated with an approved lacquer in the procedure recommended by the manufacturer. Forms so treated shall be protected from being damaged or dirtied prior to placing of the concrete.

D. Metal forms shall be treated with an approved form lacquer or may be treated with an approved form oil. The metal used for forms shall be of sufficient thickness to remain true to shape. All bolt and rivet heads shall be designed to hold the forms rigidly together and to allow removal, without injury to the concrete. Metal forms which do not have smooth surfaces, correct alignment and clean surfaces shall not be used.

E. Side forms shall not be removed for less than 12 hours after finishing has been completed.

3.4 CONCRETE PLACEMENT AND FINISHING

A. Preparation:
   1. Set forms true to line and grade and anchor rigidly in position.
   2. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Longitudinal expansion joints shall be installed between concrete sidewalk and abutting concrete curb, continuously. Transverse expansion joints shall be installed equally at not more than 25 feet on center, unless otherwise directed by the Engineer, or as detailed on the Drawings.
   3. Transverse expansion joints shall be filled with 1/2-inch joint filler strips. Joint filler shall be placed with top edge 1/4 inch below the surface and shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Protect the top edge of the joint filler during concrete placement with a temporary cap and remove after concrete has been placed.
   4. Expansion joints shall be formed about structures and features that project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. The filler shall be installed in such manner as to form a complete, uniform separation between the structure and sidewalk pavement.

B. Placement of Fabric Reinforcement:
   1. Prior to placement, clean reinforcement thoroughly of mill and rust scale and of coatings which could destroy or reduce bond. Where there is a delay in depositing concrete after the positioning of reinforcement, reclean reinforcement, if necessary.
   2. Place reinforcement midway between top and bottom of the slab and secure against displacement.

3. Lap edges and ends of adjoining sheets of fabric reinforcement at least half the mesh width. Offset end laps in adjacent sheets to prevent continuous joints at ends. Interrupt reinforcement at expansion joints, stopping 2 inches from edges.

C. Concrete Placement:

1. Concrete shall be placed in the forms in one layer of such thickness that when compacted and finished the sidewalk will be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted.
2. The concrete shall be tamped and consolidated with a suitable wood or metal tamping bar, and the surface shall be finished to grade with a wood float. Finished surface of the walk shall not vary more than 3/16 inch from the testing edge of a 20-foot straightedge. Irregularities exceeding the above shall be satisfactorily corrected. The surface shall be divided into rectangular areas by means of contraction joints spaced at intervals shown on the drawings.
3. Place concrete in accordance with ACI 301 unless otherwise specified herein.
4. Cold Weather Concreting: Comply with ACI 306 for placement at temperatures of, or expected to be, below 40°F.
5. Hot Weather Concreting: Comply with ACI 305 for placement at temperature of, or expected to be, above 90°F.

D. Concrete Finishing:

1. After straight edging, when most of the water sheen has disappeared, and just before the concrete hardens, the surface shall be finished to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, or as otherwise shown on the drawings.
2. All slab edges, including those at formed joints, shall be finished carefully with an edger having a radius of 1/8 inch. Corner and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.
3. The completed surface shall be uniform in color and free of surface blemishes and tool marks.

3.5 CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing moisture-retaining-cover curing curing compound or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.
2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm) and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period using cover material and waterproof tape.
3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.6 SEALING JOINTS

A. At the end of the curing period, expansion joints shall be carefully cleaned and filled with joint sealer. Concrete at the joint shall be surface dry, and the atmospheric and pavement temperatures shall be above 50˚F, at the time of application of joint sealing materials.

B. Joints shall be filled flush with the concrete surface in such manner as to minimize spilling on the walk surface. Spilled sealing material shall be removed immediately and the surface of the walk cleaned. Dummy groove joints shall not be sealed.

3.7 BACKFILLING AND RESTORATION

A. After curing, debris shall be removed, and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

B. All lawns, pavements, driveways, shrubs, or other improvements affected by sidewalk placement shall be restored to their original condition.

3.8 PROTECTION

A. The Contractor shall protect the sidewalk and keep it in “first class” condition until the completion of the Contract. Any sidewalk which is damaged prior to final acceptance of the Work shall be removed and replaced at the Contractor’s expense.

3.9 FIELD QUALITY CONTROL

A. Testing and Inspecting: The Owner will provide an inspecting agency to perform tests and inspections and to submit reports.

B. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., pl us one set for each additional 50 cu. yd. or fraction thereof.
   2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.

a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

3. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C23 l, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
5. Concrete Temperature: ASTM C I 064/C I 064M; one test hourly when air temperature is 40 DegF and below and when 80 DegF and above, and one test for each composite sample.
6. Compression Test Specimens: ASTM C3 l /C3 I M.
   a. Cast and laboratory cure three sets of two standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C39/C39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days. The remaining two cylinders will be held in reserve. If the results of the 28-day tests indicate low strength concrete, the engineer will direct the contractor and laboratory to test the remaining two cylinders at a time directed by the Engineer.
8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
9. Test results shall be reported in writing to Engineer, concrete manufacturer, and Owner within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28- day tests.

END OF SECTION 321630

SECTION 321723 – PAVEMENT MARKING

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes provisions for removal of existing pavement markings and for new pavement markings on finished surfaces.

1.2 REFERENCES

A. "Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering."

B. Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).

C. "Manual of Uniform Traffic Control Devices," New York State Department of Transportation.

D. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities, US Department of Justice.

1.3 SUBMITTALS

A. Pavement marking plan indicating lane separations and defined parking spaces. Note dedicated handicapped spaces with international graphics symbol.

B. One (1) manufacturer's label including product analysis for each paint type and color.

1.4 QUALITY ASSURANCE

A. Conform to all requirements of regulatory agencies having jurisdiction.

1.5 SITE CONDITIONS

A. Perform the painting operations after working hours, on weekends or at such time so as not to interfere with the flow of traffic. Provide temporary barriers to prevent vehicles from driving over newly painted areas.

B. Apply paint on dry, clean pavement surface, when the air temperature is above 40°F.

C. All pavement markings require glass bead application, except parking stall markings.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate pavement markings with regulatory authorities having jurisdiction.

B. Schedule pavement markings to follow the completion of paved surfaces.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Marking Paint: NYSDOT Section 685-2.
   1. Colors: White, yellow, blue.

B. All paints and solvent shall conform to Federal, State and Local air pollution regulations, including those for the control (emission) of volatile organic compounds (VOC) as established by the US Environmental Protection Agency, and the New York State Department of Environmental Conservation.

C. Glass Beads: NYSDOT Section 727-05, Glass Beads for Reflectorized Pavement Marking Paints.

D. Epoxy Reflectorized Pavement Markings:
   1. NYSDOT Section 727-03.

PART 3 – EXECUTION

3.1 SURFACE PREPARATION

A. Remove dust, dirt, and other foreign material detrimental to paint adhesion.

B. Mark layout of pavement markings with chalk or paint prior to final application.

C. Grind, scrape or sandblast existing pavement markings as indicated on the Drawings or as required by the Engineer. Conduct grinding, scraping, or sandblasting operations in such a manner that the finished pavement surface is not damaged or left in a pattern that will mislead or misdirect traffic. Conform to NYSDOT Section 635.

D. Painting out existing pavement markings will only be approved for short-term temporary use.

3.2 APPLICATION

A. Apply pavement markings in accordance with NYSDOT Section 685-3.05, Application for Epoxy Reflectorized Pavement Markings.

B. Reflective glass spheres are injected into, or dropped onto, the liquid epoxy marking at a minimum rate of 20 lb/gal of epoxy resin.

C. Use rollers and brushes for miscellaneous markings.

D. Use templates and guides to provide uniform patterns and straight edges.

END OF SECTION 321723

SECTION 323129 – WOODEN GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Wood gates and related work as indicated and as specified.

1.2 DEFINITIONS

A. Boards: Lumber of less than 2 inches nominal (38 mm actual) in thickness and 2 inches nominal (38 mm actual) or greater in width.

B. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) or greater but less than 5 inches nominal (114 mm actual) in least dimension.

1.3 PREINSTALLATION MEETING

A. Preinstallation Conference: Conduct conference at Project site with fabricator and installer present.

1.4 SUBMITTALS

A. Product Data:

1. Manufacturer’s technical data and installation instructions for gate hardware.
2. Product Data Sheet for all paint products.

B. Shop Drawings: Include layout, fabrication including joints and hardware as indicated, and installations shop drawings.

C. Samples:

1. Paint colors: for selection by Landscape Architect from manufacturers full range.
2. Joinery: Minimum 1 foot long, full height samples of picket, post, and railings, showing mortise and tenon joinery.

D. Certificates

1. For lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by ALSC's Board of Review.
2. Submit Wood Certificates of Inspection: Issued by lumber grading agency for exposed wood products not marked with grade stamp.
3. Carpenter Qualifications and client contacts.

1.5 QUALITY ASSURANCE

A. Qualifications for Carpenter: Engage an experienced Carpenter who has at least five years' experience with mortise and tenon joinery and has completed at least five projects including gates with similar material and scope to that indicated for this Project with a successful construction record of in-service performance. Provide contact information for projects.

1.6 PRODUCT HANDLING

A. Keep materials under cover and dry. Protect against exposure to weather and contact with damp or wet surfaces. Provide for air circulation within and around stacks and under temporary coverings including polyethylene and similar material.

B. Paint

1. Store products in manufacturer's unopened packaging until ready for installation.
2. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.
3. Disposal:

    a. Never pour leftover coating down any sink or drain. Use up material on the job or seal can and store safely for future use.
    b. Do not incinerate closed containers.
    c. For specific disposal or recycle guidelines, contact the local waste management agency or district. Recycle whenever possible.

1.7 PROJECT CONDITIONS / COORDINATION

A. Fit wood gates to other work to ensure an accurate fit.

B. Do not install gate footings when ground is wet or frozen.

C. Paint: Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

D. Coordinate installation with adjacent paving and planting schedules.

1.8 WARRANTY

A. Paint

1. Inspection of all surfaces to be coated must be done by the paint manufacturer's representative to ensure proper preparation prior to application. All thinners, fillers, primers and finish coatings shall be from the same manufacturer to support a product warranty. Products other than those submitted shall be accompanied by a letter stating its fitness for use and compatibility.

2. At project closeout, provide to the Director’s Representative an executed copy of the Manufacturer's standard form outlining the terms and conditions of and any exclusions to their Limited Warranty against Manufacturing Defect.

B. Gate Fabrication: One year on parts and labor beginning at final approval.

1.9 EXTRA MATERIALS

A. At project closeout, supply the Director’s Representative one gallon of each paint product for touch-up purposes. Cans shall be clearly marked with color name, number and type of paint.

B. At project closeout, provide the color mixture name and code to the Director’s Representative for accurate future color matching.

PART 2 - PRODUCTS

2.1 WOOD, GENERAL

A. Comply with DOC PS 20 and with grading rules of lumber grading agencies certified by ALSC's Board of Review as applicable. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by ALSC's Board of Review.

1. Factory mark each item with grade stamp of grading agency.
2. For items that are exposed to view in the completed Work omit grade stamp and provide doucertificates of grade compliance issued by grading agency.
3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
4. Provide dressed lumber, S4S, unless otherwise indicated.

B. Maximum Moisture Content:

1. Boards: **15** percent.
2. Dimension Lumber: **15** percent for 2-inch nominal (38-mm actual) thickness or less; 19 percent for more than 2-inch nominal (38-mm actual) thickness.)

C. Wood shall be Eastern Red Cedar (*Juniperus virginiana*) Select (S4S) No knots.

2.2 POSTS

A. Dimensions:4 inches by 4 inches nominal

2.3 ARCH

A. Provide radially cut segments; 4 inches by 4 inches

B. Joinery: Mortise and tenon.

2.4 PICKETS

A. Surface mounted.

B. Dimensions: 1.75” by 2” nominal; length as indicated.

C. Picket Points: 2 inches, eased point.

2.5 RAILS & END PICKETS

A. Dimensions: 2” by 4” nominal

B. Joinery: Mortise and tenon

2.6 CROSS BRACE

A. Dimensions: 1.25” by 2” nominal

B. Connection: Half lap-at mid-point

2.7 HARDWARE

A. Basis of Design for historic hardware: Hinge & Latch or approved equal.

1. Contact
Phone: 877-422-2042
https://www.hingeandlatch.com/

B. Hinges: Butt hinges dimensions as indicated.

1. Color: paint to match fence.

C. Latches: Twisted Ring Gate Latch - Set Back Design; Item #4152-L6SP & 4152-LESP

1. Bar, catch and retainer: 304 Stainless
2. Rings and rosettes: aluminum/zinc alloy
3. Color: black

D. Single Gate:

1. Gate Spring: “Brutus”:

a. 1-1/8 inch diameter by 10-1/2 inch long spring
b. Total length 13-1/2 inch including mounting brackets
c. Top tension pin type tightener

d. 305 stainless steel
e. Color: Black

E. Double Gate:

1. Cane Bolt: 24" Stainless Steel Cane Bolt; Part Number 4096-24SS/24SC

a. Color: Black.

2. Cannonball Gate Closer: (#CBP) and gate stop (item #1400-BSS) Parts include:

a. 1 – 80 mm solid cast iron ball with eye
b. 1 – 60-inch length of 3/16 inch BPPCG chain
c. 1 – ¼ inch quick link to attach the ball to the chain
d. 2 – galvanized fence staples for attaching the ends of the chain.
e. Mounting Kit (#CBP-MK):

1 – BPPCG staple on 2 inch plate – (#3487-00SP)
1 – BPPCG hook on 2 inch plate – (#3486-00SP)
1 – 3036-23P – Black 1/3 inch quick link

f. Color: Black.

F. Other hardware:

1. If indicated on the approved shop drawing, hot-dipped galvanized carbon steel; dimensions as indicated.
2. Use attaching hardware provided for each type of latch, hinge, closer, and bolt.

2.8 PAINT FOR WOOD

A. General:

1. Compatibility: Primer and finish coats shall be from a single source. Provide materials that are compatible with one another, and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
2. Except where specifically noted in this section, all paint shall be ready-mixed and pre-tinted. Agitate all paint prior to and during application to ensure uniform color, gloss, and consistency.
3. Thinner addition shall not exceed manufacturer's printed recommendations. Do not use kerosene or other organic solvents to thin water-based paints.
4. Where paint is to be sprayed, thin according to manufacturer's current guidelines.
5. Field Touch-up shop applied coatings that are damaged during handling, and shipping, or from stacking and erection of members at the jobsite.

B. Acceptable Manufacturer

1. Benjamin Moore and Co.,
101 Paragon Dr., Montvale, NJ 07645
Toll Free Tel: 866-708-9181

Email: info@benjaminmoore.com
Web:www.benjaminmoore.com

2. Or approved equal.

C. Primer

1. One coat to be applied before assembly.
2. Benjamin Moore Fresh Start® Deck and Siding Primer 094.

D. Finish Coats (2)

1. Benjamin Moore Exterior Aura® Exterior Low Lustre N634.
2. Color: Frostine AF-5.

2.9 CONCRETE

A. Refer to Section 033000 – "Cast-in-Place Concrete".

2.10 MISCELLANEOUS

A. Glues for mortise and tenon: Compatible with Eastern Red Cedar and resistant to damp conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine openings to receive gates, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect surrounding plant materials and hardscape.

3.3 INSTALLATION

A. Do not use lumber of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned or too small to fabricate the Work with a minimum of joints or the optimum jointing arrangement.

B. Do not begin gate installation and erection before the final grading is completed, with finish elevations established, unless otherwise permitted in writing by the Director's Representative.

C. Excavation: Drill or hand-excavate (using post-hole digger) to uniform diameters at the spacing required, in firm, undisturbed or compacted soil.

D. Setting Posts: Center and align posts in holes at correct height, place on 6" of compacted #57 stone placed on the bottom of excavation unless otherwise indicated.

1. Place concrete around posts and vibrate or tamp for consolidation.
2. Check each post for vertical top alignment and hold in position during placement and finishing operations.
3. Protect portion of posts above ground from concrete splatter.
4. Unless otherwise indicated, extend concrete footings 1 inch above grade and trowel to a crown to shed water.

E. Concrete Strength: Allow concrete to attain at least 75% of its minimum 28-day compressive strength, but in no case sooner than 7 days after placement.

F. Fit gate to other Work. Scribe and cope as required for accurate fit.

G. Set gate accurately to required levels and lines with members plumb and true.

H. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting the wood; predrill as required.

3.4 PAINT FOR WOOD

A. Prepare substraights.

1. Clean thoroughly to remove dirt, mold and any mildew then allow to dry for several days. Ideally, re-check moisture levels. Remove mil-glaze either mechanically with the grain using 60-80 grit sandpaper blower or using a chemical cleaner that is specific to removing mil-glaze and opening the woodgrain. Dust from sanding should be swept or blown away with a leaf blower.
2. Prime edges, ends, faces, undersides, and backsides of wood.
3. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

B. Prime all wood before assembly.

1. Apply primer per manufacturer's instructions.
2. Apply intermediate when primer has dried for at least 4 hours but no longer than 1 week.
3. If assembled gates are not finished within 1 week of applying primer, sand surfaces per paint manufacturer's written instructions before proceeding with the finish coats.

C. Intermediate Coat

1. Apply one coat of finish paint to the assembled gate before installation.

2. Allow to dry per manufacturer's instructions. Allow for additional time if conditions such as humidity slow process.

D. Finish Coat

1. Apply one coat of finish paint in the field when gate posts have been installed but before hinges and latches are installed.

3.5 REPAIR AND CLEAN UP

A. Sand to smooth any splinters and rough edges to the satisfaction of the Director's Representative.

B. Remove and replace any wood that has been damaged and cannot be repaired to "like new" condition in the opinion of the Director's Representative.

C. Touchup Painting: Immediately after erection, clean connections and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop painted surfaces.
1. Areas where touchup paint is applied should be indistinguishable from the original finish.
2. The Director's Representative will be the final judge of finish quality.

D. Remove surplus soil and waste material including excess subsoil, unsuitable soil, wood, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 024119

SECTION 329115 - SOIL PREPARATION (PERFORMANCE SPECIFICATION)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes planting soils specified according to performance requirements of the mixes.

B. Related Requirements:

1. Section 044102 “Raised Dry-Laid Planters” for placing planting soil in exterior stone unit planters.
2. Section 129301 “Custom Site Furnishings – Wooden Planter for placing planting soil in exterior wood unit planters.
3. Section 323300 "Site Furnishings" for placing planting soil in exterior unit planters.
4. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
5. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
6. Section 329220 “Herbaceous Seeding” for placing planting soil for seeded meadow
7. Section 329300 "Exterior Plants" for placing planting soil for plantings.
8. Section 329600 "Transplanting" for placing planting soil in tree planting pits.

1.2 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. 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.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Topsoil/Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at **Project site**.

1.4 ACTION SUBMITTALS

A. Product Data: For each planting soil mix.

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of imported soil and soil before delivery to the site, according to the following:

    a. Manufacturer's qualified testing agency's certified analysis of standard products.
    b. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-quart (1-L) volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 PLANTING SOILS SPECIFIED ACCORDING TO PERFORMANCE REQUIREMENTS

A. Imported Planting Soil: Imported, naturally formed soil from off-site sources and consisting of loam according to USDA textures; and modified to produce viable planting soil. Amend imported soil with materials specified in other articles of this Section to become planting soil complying with the following requirements:

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep, not from agricultural land**,** bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, loosestrife, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, Japanese knotweed, phragmites, perennial sorrel, mugwort, garlic mustard, bromegrass and others particular to the project area and defined by the Director's Representative..
2. Additional Properties of Imported Soil before Amending: Minimum of **6** percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration. Clean soil to be of the following:

    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth as determined by the Director's Representative.
    b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
    c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches (50 mm) in any dimension.

2.2 PLANTING SOILS MIX FOR TREES AND SHRUBS

A. Topsoil:

1. Loam.

B. Particle Size Distribution by Separates:

1. Total Sand: approximately 40%
2. Silt: approximately 40%
3. Clay: 20% maximum

C. Fragment Size Distribution for Trees and Shrubs:

GRADATION	
Sieve Size	Percent Passing by Weight
2 inch	100
1 inch	85-100
¼ inch	65-100
No.200	20-40
2 micron	5-35

D. Percentage of Organic Matter:

1. Planting areas: Minimum 10 percent and no more than 15 percent by volume.

E. Soil Reaction:

1. Planting areas: pH of 5.5-7.0.

2.3 PLANTING SOILS MIX FOR MEADOWS

A. Topsoil

1. Sandy loam.

B. Particle Size Distribution by Separates:

1. Total Sand: approximately 40%
2. Silt: approximately 40%
3. Clay: 20% maximum

C. Fragment Size Distribution for Trees and Shrubs:

GRADATION	
Sieve Size	Percent Passing by Weight
2 inch	100
1 inch	85-100
¼ inch	65-100
No.200	20-40
2 micron	5-35

D. Percentage of Organic Matter:

1. Planting areas: Minimum 10 percent and no more than 15 percent by volume.

E. Soil Reaction:

1. Planting areas: pH of 5.5-7.0.

2.4 PLANTING SOILS MIX FOR LAWNS AND GRASSES

A. Topsoil:

1. Sandy loam.

B. Particle Size Distribution by Separates:

1. Sand: 40% to 75%
2. Silt: 15% to 65%
3. Clay: 20% maximum

C. Fragment Size Distribution for Lawns and Grasses:

GRADATION	
Sieve Size	Percent Passing by Weight
1 inch	100
No. 10	90-100
No. 40	45-80
No.200	25-70

2 micron	5-35

D. Percentage of Organic Matter:

1. Lawns: Minimum 3 percent and no more than 8 percent by volume.

E. Soil Reaction:

1. Lawns: pH of 5.5 to 7.5

2.5 PLANTING SOILS MIX FOR RAISED GARDEN BEDS

A. Commercial Mix for Raised Garden Beds

2.6 PLANTING SOILS MIX FOR PLANTERS AND URNSRAISED GARDEN BEDS

A. Commercial Potting Soil Mix

B. Meadow Seeding Areas: No soil amendments shall be used for meadow plantings unless accepted in writing by the Director's Representative and the Landscape Architect.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 > percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

3.3 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of 4 inches Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top 4 inches (100 mm) of subgrade. Spread remainder of planting soil.

C. Application: Spread planting soil to total depth of 6 inches but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

D. Compaction: Compact each lift of planting soil to **75** percent of maximum Standard Proctor density according to ASTM D698

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. Space tests at no less than one for each 1000 sq. ft. (100 sq. m) of in-place soil or part thereof.
2. Performance Testing: For each amended planting-soil type, demonstrating compliance with specified performance requirements. Perform testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

C. Soil will be considered defective if it does not pass tests.

D. Prepare test reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.5 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.

7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is over compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.6 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329115

SECTION 329200 - LAWNS AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Seeding.
2. Lawn renovation.
3. Sodding.

B. This Section does not include herbaceous seeding, which can be found in Section 329220 “Herbaceous Seeding.”

C. Related Sections include the following:

1. Section 311100 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 311200 "Earth Moving" for excavation, filling and backfilling, and rough grading.
3. Section 329300 “Soil Preparation (Performance Specification)
4. Section 329220 “Herbaceous Seeding.”

1.2 SUBMITTALS

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

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and 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 identifying source, including name and telephone number of suppliers.

C. Product Certificates: For soil amendments and fertilizers, signed by product manufacturer.

D. Qualification Data: For landscape Installer.

E. Planting Schedule: Indicating anticipated planting dates for each type of planting.

F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of lawns during a calendar year. Submit before expiration of required maintenance periods.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time English-speaking supervisor on Project site when planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent 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. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for lawn growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce a satisfactory topsoil.

D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in TPI's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its "Guideline Specifications to Turfgrass Sodding."

1.5 SCHEDULING

A. 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: March 1 to June 15
2. Fall Planting: October 1 to December 1

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.6 LAWN MAINTENANCE

A. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:

1. Seeded Lawns: **60** days from date of Substantial Completion.

    a. When full maintenance period has not elapsed before the end of planting season, or if lawn is not fully established, continue maintenance during next planting season.

2. Sodded Lawns: 30 days from date of Substantial Completion.

B. Maintain and establish lawn by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and re-mulch to produce a uniformly smooth lawn.

1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch. Anchor as required to prevent displacement.

C. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches (100 mm).

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
2. Water lawn at a minimum rate of 1 inch (25 mm) per week.

D. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 40 percent of grass height. Remove no more than 40 percent 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 grass 2 to 3 inches (50 to 75 mm) high.

E. Lawn 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. (0.45 kg/92.9 sq. m) to lawn area.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species: State-certified seed of grass species.

Common Name	Scientific Name	Variety	Percent by Weight
Kentucky Bluegrass (2 var. min.)	*Poa pratensis* L. var.	Commercial	15 – 40
Fine Fescue (Chewings, Hard, Sheep, Slender Creeping and Strong Creeping) – 2 var. min.; must include creeping red	*Festuca rubra* var. *196ommutate* Gaud., *Festuca longifolia, Festuca ovina* L., and *Festuca rubra* L. var.	Commercial turf	30 – 50
Perennial Ryegrass (2 var. min.)	*Lolium perenne* L. var.	Commercial turf	15 – 40
Italian (Annual) Ryegrass	*Lolium multiflorum* Lam.	Commercial	5 – 15

2.2 TURFGRASS SOD

A. Turfgrass Sod: Certified, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with TPI's "Specifications for Turfgrass Sod Materials" in its "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: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:

1. Sun and Partial Shade: Proportioned by weight as follows:

a. 50 percent Kentucky bluegrass (*Poa pratensis*).
b. 30 percent chewings red fescue (*Festuca rubra* variety),
c. 10 percent perennial ryegrass (*Lolium perenne*).
d. 10 percent redtop (*Agrostis alba*).

2.3 TOPSOIL

A. Refer to Section 329300 “Soil Preparation (Performance Specification)

2.4 PLANTING ACCESSORIES

A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.5 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Compost 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-inch (25-mm)

sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: **50 to 60** > percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

C. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.

D. Fiber mulch above and nonasphaltic tackifier below are used primarily to protect hydroseeded areas from wind and water erosion during establishment.

E. Non-asphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

2.6 EROSION-CONTROL MATERIALS

A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

B. Erosion-Control Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, a minimum of 0.92 lb/sq. yd. (0.5 kg/sq. m), with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance. 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 adjacent and adjoining areas from hydroseeding overspray.

B. Provide 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.

3.3 SOIL PREPARATION

1. Refer to Section 329300 “Soil Preparation (Performance Specification)

B. SEEDING

C. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.

1. Do not use wet seed or seed that is moldy or otherwise damaged.

D. Sowing rates vary with grass species and mixtures. Revise first paragraph below to suit Project.

E. Sow seed at the rate of 5 to 8 lb/1000 sq. ft. (2.3 to 3.6 kg/92.9 sq.m).

F. Rake seed lightly into top 1/8 inch (3 mm) of topsoil, roll lightly, and water with fine spray.

G. Protect seeded areas with slopes exceeding 1:6 with erosion-control fiber mesh and 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.

H. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre (42 kg/92.9 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into topsoil with suitable mechanical equipment.
2. Bond straw mulch by spraying with asphalt emulsion at the rate of 10 to 13 gal./1000 sq. ft. (38 to 49 L/92.9 sq. m). Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

I. Below is usually required in warm, dry climates.

J. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak and scatter uniformly to a depth of 3/16 inch (4.8 mm) and roll to a smooth surface.

3.4 HYDROSEEDING

A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with non-asphaltic tackifier.
2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply mulch at a minimum rate of 1500-lb/acre (15.3-kg/92.9 sq. m) dry weight but not less than the rate required to obtain specified seed-sowing rate.

3. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry application at a minimum rate of 500-lb/acre (5.1-kg/92.9 sq. m) dry weight but not less than the rate required to obtain specified seed-sowing rate. Apply slurry cover coat of fiber mulch at a rate of 1000 lb/acre (10.2 kg/92.9 sq. m).

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. Remove netting prior to sod installation.

C. 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 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.

D. Saturate sod with fine water spray within two hours of planting. During first week, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.6 LAWN RENOVATION

A. Renovate existing lawn.

B. Renovate existing lawn damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

1. Reestablish lawn where settlement or washouts occur or where minor regrading is required.

C. Remove sod and vegetation from diseased or unsatisfactory lawn areas; do not bury in soil.

D. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.

E. Mow, dethatch, core aerate, and rake existing lawn.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches (150 mm).

I. Apply soil amendments and initial fertilizers required for establishing new lawns and mix thoroughly into top 4 inches (100 mm) of existing soil. Provide new planting soil to fill low spots and meet finish grades.

J. Apply seed and protect with straw mulch as required for new lawns.

K. Water newly planted areas and keep moist until new lawn is established.

3.7 SATISFACTORY LAWNS

A. Satisfactory Seeded Lawn: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 3 by 3 inches (76 by 76 mm).

B. Satisfactory Sodded Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable lawn has been established, free of weeds, open joints, bare areas, and surface irregularities.

C. Reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

3.8 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by lawn work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades throughout maintenance period and remove after lawn is established.

C. Remove erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 329220 – HERBACEOUS SEEDING

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. Meadow Seed Mix
2. Bioretention Seed Mix.

B. Related Requirements:

1. Section 329115 “Soil Specification (Performance Specification)
2. Section 329300 "Exterior Plants" for trees, shrubs, ground covers other than turf, and other plant material.
3. Section 329200 “Turf and Grasses”

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Management Period: Time frame that begins after seeding occurs and ends at acceptance of the seeded area.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds/invasive species), fungi, bacteria, and viruses.

D. Planting Soil: Imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329115 "Soil Preparation (Performance Specification)" and drawing designations for planting soils.

E. Pure Live Seed (PLS): PLS is a means of expressing seed quality. PLS is the percentage of seed (i.e. good viable seed) that has the potential to germinate within a measured one pound weight of any seed lot, expressed in pounds per acre as the basis for the calculation of seeding rates.

F. Stand of Accepted Plants from Seed: A healthy, uniform, close stand of plants that meet the following criteria: A minimum of 8 thriving desirable plants per square foot (excluding nurse crop; no bare or dead spots over 16 inch maximum in any dimension; no more than 10 percent of the area is bare; free from disease, and detrimental insect infestation; no more than 5 percent of the meadow is covered in target weeds.

G. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

H. Target Weeds: plants including, but not limited to: *Alliaria petiolate* (garlic mustard), *Lonicera japonica* (Japanese Honeysuckle), *Toxicodendron radicans* (Poison Ivy), *Rubus phoenicolasius* (Wineberry), *Similax rotundifolia* (Round Leaf Greenbriar), *Celastrus orbiculatus* (Oriental Bittersweet), *Ailanthus altissima* (Tree-of-Heaven), *Robinia pseudoacacia* (Black Locust), *Lythrum salicaria* (Purple Loosestrife), *Acer platanoides* (Norway Maple), *Prunus avium* (Sweet Cherry), and *Ulmus pumila* (Siberian Elm).

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site. Pesticide applicator, Meadow installer, Director's Representative, Landscape Architect are required.

1.5 INFORMATIONAL SUBMITTALS

A. Submit a Schedule and Procedures within 2 weeks of contract award, for the installation, establishment and maintenance of the meadow for review and approval by the Director's Representative and Landscape Architect.

B. Meadow Mix seed: certification of mix proportions, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity (PLS), germination, and weed seed. Include the year of production, date of packaging and viability date.

C. Meadow Mix Seed: Installation methods (including equipment) and schedule.

D. Source Identification:

1. Submit a complete list of all seed material for Project with source identification for each seed variety. Include name, address, and phone number of seed source. Purchase all seeds from the same source.

E. Documentation of Unavailability of Seed Material: Before changes or substitutions are made due to unavailability of seed material, the Contractor shall submit satisfactory evidence that he/she has been unable to locate the specified material and has undertaken other methods of locating seed material acceptable to the Director's Representative and Landscape Architect.

F. Qualifications Data: for Pesticide/Herbicide Applicator, Seed Installer, Seed Supplier.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of meadows during a calendar year (after the maintenance period). Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Seed Installer: A qualified landscape installer whose work has resulted in successful establishment of native meadows from plant and seed on at least three projects of similar size and complexity.
2. Experience: Five (5) years experience in reforestation and the installation of meadow seed by hand.
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time, English-speaking supervisor with a minimum of five years' experience on Project site when work is in progress.

B. Seed Supplier qualifications: Minimum 10 years in business.

C. Pesticide Applicator Qualifications: State licensed, commercial.

D. The Landscape Architect shall have the right to reject any seed supplier if they determine, before, during or after inspecting or receipt of seed, any of the following:

1. The seed do not meet the quality standards set forth herein.
2. The suppliers cannot supply the specified seed and are substituting species without approval.

1.8 DELIVERY, STORAGE, AND HANDLING

A. General:

1. Deliver materials only after preparation for on-site seeding has been completed and accepted, including but not limited to: preparation for final seeding, rough grading and soil installation.
2. Prohibit traffic and construction on or around areas to be seeded.
3. Prohibit storage of any equipment or materials on area to be seeded once clearing has begun.

B. Seed:

1. Seed shall be stored at temperatures between 40- and 60-degrees F and with a relative humidity of between 25-60%.
2. Seed that has become wet or moldy shall not be accepted.
3. Transport: Temperature shall not exceed 105 F at any time. If transit from cold storage to sowing is greater than 10 days, seed must be kept under storage temperatures and

relative humidity described above. Follow seed provider written instructions and best practices for seed storage.

C. Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

D. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing 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 materials with appropriate certificates.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

B. Concealed Conditions: Notify Director’s Representative before planting when below grade conditions detrimental to proper plant growth are encountered. Do not proceed with seeding or planting without specific written instructions from the Landscape Architect.

C. Should any damage occur, the Contractor shall repair elements to the Director’s Representative and Landscape Architect’s satisfaction.

D. Restrict traffic from meadow areas until they are established. Erect signs and barriers as required. Any damage to the meadow that occurs because of traffic or lack of protection of the meadow areas shall be repaired by the contractor at no additional cost.

1.10 SCHEDULING

A. In Season Seeding: May 1 to June 30 (Growing Season Seeding) and November 1 to December 31 (Dormant Season Seeding).

B. Out of Season Seeding: January 1 and April 30 or between July 1 and October 31.

1. Increase seed volume by 25 percent for seeding

1.11 FINAL ACCEPTANCE

A. General

1. Final Acceptance occurs after all items have been approved by the Director’s Representative/Landscape Architect.

2. Partial acceptances will not be granted.
3. The request for inspection shall be received in writing at least ten calendar days before the anticipated date of inspection. Do not request inspection for acceptance until installation work for the activity is 100% complete and past the 120 growing days needed for meadow acceptance. Project must be in compliance with the Contract requirements. Acceptance of seed and plant material by the Director's Representative/Landscape Architect shall be for general conformance to specified size, character and quality and not relieve the Contractor of responsibility for full conformance to the contract documents, including correct species.
4. The Contractor is responsible for the condition and quality of work and materials during construction, and until Acceptance. Contractor shall bear the total cost of replacing any and all plant material until this time.

B. Site Preparation Acceptance

1. Prior to seeding, the site must be inspected by Director's Representative to ensure that weed control is acceptable, seed bed is in appropriate condition for seeding and the site has been correctly delineated.
2. If it is determined that conditions are not acceptable for seeding, these areas should be mitigated and inspected by Director's Representative and Landscape Architect prior to seeding.

C. Seeding Acceptance

1. After seeding, the site must be inspected by Director's Representative/Landscape Architect to ensure that seeding has been completed per specifications.
2. If the seeding is not in conformance, the Contractor shall correct non-conforming items prior to a follow-up inspection by the Director's Representative. Acceptance will be confirmed in writing.
3. Acceptance of the seeding shall be for general conformance to quality and shall not relieve the Contractor of responsibility for full conformance to the Contract Documents, including correct species.

D. Meadow Acceptance

1. 120 days from the date of initial germination, the meadow areas shall be an acceptable stand of meadow which is defined to mean a uniform coverage with well established, close stands of plants that meet the following criteria:

    a. A minimum of 8 thriving desirable plants per square foot (excluding nurse crop).
    b. No bare or dead spots over 36" maximum in any dimension.
    c. No more than 10% of the meadow is bare.
    d. Free from disease, and detrimental insect infestation.
    e. No more than 5% of the area is covered in targeted weeds and/or undesirable vegetation.

1.12 WARRANTY

A. Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship for the specified periods. "Defects" is defined to include, but is not limited to,

death, unsatisfactory growth, failure to adequately root into soil, disease, abnormal size, abnormal color, failure to thrive, and other unsatisfactory characteristics.

B. Meadow Replacement: Replace defective meadow with new seeding that will provide plants of same type, species, character, and quality of originally accepted work. If a replacement is unacceptable during its one-year warranty, the Contractor shall provide another.

1. Perform soil tests for soil biology, compaction, and infiltration to determine the reason for failure and correct any defects before replacing meadow. Provide as many tests as needed to determine cause for failure.
2. Replacement: Planting for replacement and warranty work for seeding shall comply with calendar and methods specified herein.
3. Plants are warrantied under this section..

C. Warranty for Seeded Meadows:

1. Warranty Period shall be 1 year from date of acceptance.
2. Owner Responsibility and Warranty Exclusions:

a. The Contractor’s warranty shall exclude problems due to improper or inadequate management, vandalism or acts of nature.

1) During the warranty period the Contractor shall visit the site at least three times during the growing seasons to review the conditions of the accepted work. The Contractor shall submit in writing to the Owner regarding the Owner’s management practices and/or any vandalism. The content of this notice shall include a list of specific plants involved, the presumed problem, and a method of remedy for the problem(s) cited. The Owner shall make reasonable efforts to correct the problems cited by the Contractor, but the Owner shall not be held responsible for the Contractor’s defects in materials or workmanship that result in decline or death to plants.
2) Failure of the Contractor to make the required reviews of the site during the warranty period and to submit written notice to the Owner of management defects shall negate the Contractor’s ability to make a claim against the Owner for negligence of management.

PART 2 - PRODUCTS

2.1 SEED

A. Provide New York, Connecticut, or New Jersey certified Endophyte-enhanced seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weed seed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. No field mixes will be permitted.

B. Seed Mix Suppliers:

1. Ernst Conservation Seeds, Inc., 8884 Mercer Pike, Meadville PA 16335, Tel: 800-873-3321, http://www.ernstseed.com/.
2. Prairie Moon Nursery, 32115 Prairie Lane, Winona, MN 55987. Tel: (886)417-8156, www.prairiemoon.com.
3. Greenbelt Native Plant Center, 3808 Victory Blvd., Staten Island, NY 10314. Tel: 718-370-9044, www.greenbeltnativeplantcenter.com .
4. Or equal approved by the Landscape Architect.

C. Seed Mixes:

1. Provide the species at the percentages as indicated in the drawings.
2. Seed mixes shall be delivered in individual bags labeled by mix.

2.2 SEED BULKING AGENT

A. Seed Hand Broadcasting Bulking Agent: Fine premium pine shavings. Provide one of the following, or approved equal:

1. Provide: Tractor Supply Flake Premium Pine Animal Shavings, Tractor Supply Co., Tractorsupply.com; Agway Premium Pine Shavings, Agway, Agway.com; or America's Choice Medium Flake Bedding, Petco, Petco.com or approved equal.

2.3 PLANTING SOIL

A. Refer to 329115 “ Soil Preparation (Performance Specification)”.

2.4 PLANTING SOIL AMENDMENTS

A. Soil amendments shall not be used for meadow plantings unless accepted in writing by the Director’s Representative/Landscape Architect.

2.5 WATER

A. Source of water shall be approved by Director’s Representative and of suitable quality for irrigation, containing no elements toxic to plant life. Contractor shall be responsible for maintaining new seeded plant growth by periodic irrigation and mowing until the project is accepted by the Director’s Representative.

B. Verify that water is available on site for mixing seed. Provide water tank trucks if water is not available on site for seed mixing.

2.6 CHEMICAL AND BIOLOGICAL ADDITIVES

A. No fertilizer will be applied during meadow plantings or in areas to be converted to meadow during any part of the project.

2.7 EQUIPMENT

A. Walk behind equipment (seeders / Harley rake) as needed to prepare areas

B. 3 bin No-Till Drill Seeder may be used on slopes less than 3:1.

C. Contractor may suggest alternative types of equipment to be approved by the Director's Representative and Landscape Architect.

PART 3 - EXECUTION

3.1 SCHEDULE

A. All herbaceous seed planting must be completed by Spring of 2025. If Contractor cannot comply, Contractor must provide an alternative seeding schedule to the Director's Representative for approval.

3.2 EXAMINATION

A. Only experienced workers, under the supervision of a qualified foreman, shall execute clearing and seeding operations. Seeding shall consist of soil preparation, weed management, and otherwise providing all labor and materials necessary to secure the establishment of acceptable vegetative layer.

B. Before beginning any establishment phase, the Contractor shall examine conditions under which this work is to be performed and notify the Director's Representative in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions. The Contractor shall not commence work associated with the installation of Meadows until all work in the work areas is complete and accepted by the Director's Representative. The Contractor shall confirm that:

1. Planting soil is installed and has been accepted.
2. Fine grading is accepted and remains free of debris.
3. Any woodchips have been removed from site.
4. Area is free of weeds.
5. Verify that sufficient means for on-site watering of installed seed and plants are available.

C. Proceed with seeding operations only after unsatisfactory conditions have been corrected and all approved treatment for the removal of invasives has been completed.

D. 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 Director's Representative and replace with new planting soil.

3.3 PREPARATION

A. Ensure contractor is authorized to begin seeding operations.

B. Confirm with Director's Representative the extent and distribution of the seeding areas.

C. Seed only when areas are in friable condition and neither hard, muddy, wet, or frozen.

D. Do not seed when wind speeds exceed 5 mph.

E. Protect structures, utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

3.4 SITE PREPARATION

A. The seedbed must be firm and clear of actively growing weeds before planting meadow.

B. A properly compacted seedbed should not allow a shoe to sink more than 1/2 inch when walking on the seedbed.

C. Director's Representative must inspect site prior to seed installation and provide site preparation acceptance.

D. If process starts and seeding is delayed by longer than 1 month, sow approved cover crop and start process again.

E. If any trees or shrubs need to be placed after seeding, contractor shall overseed all disturbed soil plus a 5' buffer of the appropriate seed mix at the appropriate rate

3.5 SEEDING

A. Install seed mix according to the timeline established by this document.

A. Prior to seeding and planting verify meadow area is prepared and ready for vegetation installation. Review area with Director's Representative and Landscape Architect before beginning work.

1. Cut and/or spray all weeds from meadow planting areas prior to start of any seeding sequence as listed in this document.
2. Fine grading has been accepted by the Director's Representative.

B. Before any seeding takes place, run over area to be seeded with walk behind power rake (Harley or other) attached to a tracked skid steer or other appropriate equipment to scarify soil to approximate ½".

1. Use metal rakes around trees, shrubs and any other areas where machine access is not possible.

C. Apply seed immediately upon completion of site preparation and approval by Director's Representative and Landscape Architect.

D. Seed Application Method

1. Seeding method shall be with a no-till drill seeder or hand-seeding based on the timing and slope as indicated above and as per the written schedule approved by the Landscape Architect and Director's Representative.

3.6 CLEANUP AND PROTECTION

A. Promptly remove soil and debris created by the work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.

D. Do not operate equipment or vehicles on newly planted areas.

3.7 MAINTENANCE

A. General: Maintain and establish meadow by watering, weeding and performing other operations as required to establish healthy, viable meadow.

B. Frequency of Maintenance

1. Begin maintenance immediately after seed begins to germinate.. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

C. Weed Control – General
1. (2025Weeds shall never exceed 12 inches in height during Maintenance/Warranty Period.
2. Weed species shall never be allowed to set seed.

D. Weed Control – High Priority

1. The following invasive plants are in the immediate area and are particularly aggressive and need to be selectively cut or trimmed on a bi-weekly basis:

- *Alliaria petiolate* (Garlic Mustard)
- *Lonicera japonica* (Japanese Honeysuckle)
- *Toxicodendron radicans* (Poison Ivy)
- *Rubus phoenicolasius* (Wineberry)
- *Similax rotundifolia* (Round Leaf Greenbriar)
- *Celastrus orbiculatus* (Oriental Bittersweet)
- *Ailanthus altissima* (Tree-of-Heaven)
- *Robinia pseudoacacia* (Black Locust)
- *Acer platanoides* (Norway Maple)
- *Prunus avium* (Sweet Cherry)

- *Ulmus pumila* (Siberian Elm).
- *Rosa multiflora* (Multiflora Rose)
- *Berberis thunbergia* (Japanese Barberry)
- *Cirsium arvense* (Canad Thistle)
- *Caragana arborescens (*Siberian Peashrub)

2. A final list shall be finalized by the Director's Representative at the start of the Management Period.

E. Meadow Mowing

1. The height of the meadow is measured from the soil. Perform mowing of the meadow in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on the meadow area shall be picked up and disposed. Adjacent paved areas shall be swept/vacuumed clean.

F. Seeded Meadow - First Growing Season (2025)

1. Do not cut the meadow until a meadow establishment schedule has been submitted and approved by the Director's Representative and Landscape Architect and height has been agreed upon in writing. Use flail or rotary-style equipment that will chop dead growth. Sickle bar type mowers that cut at the base of vegetation and drop plant material intact should not be used as the intact cut plant material can inhibit seedling development.

   a. In areas with live plants or woody plants, hand cut or string trim weeds.
   b. In locations inaccessible to a mower (wet areas, steep slopes, etc.), string trim vegetation to the specified height.
   c. Leave cut material as it returns organic matter and nutrients to the soil. Any thick accumulations of cut material that remain to the point where soil cannot be observed through the cut material should be dispersed evenly over the site or removed.

G. Seeded Meadow – Subsequent Growing Season (2026)

1. Prior to the emergence of new spring growth, mow previous year's herbaceous growth to approximately 4 inches to 6 inches. Use flail or rotary-style equipment that will chop dead growth. Sickle bar type mowers that cut at the base of vegetation and drop plant material intact

END OF SECTION 329220

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SECTION 329300 - EXTERIOR PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Trees.
2. Shrubs.
3. Ground covers.
4. Planting Accessories.
5. Mulch.
6. Maintenance and Warranty of Exterior Plants.

B. Related Sections include the following:

1. Section 015639 “NYS Temporary Tree and Plant Protection” for installation of aeration tubes for existing trees where the grade has been raised.
2. Section 311000 "Site Clearing" for topsoil stripping and stockpiling, and site clearing.
3. Section 312000 “Earth Moving for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
4. Section 015639 “Temporary Tree and Plant Protection”.
5. Section 329115 “Soil Preparation (Performance Specification)”
6. Section 329200 “Turf and Grasses” for turfgrass plantings.
7. Section 328220 “Herbaceous Seeding” for meadow and wildflower seeding.
8. Section 329600 “Transplanting” for transplanting of non-nursery trees.

1.2 STANDARDS

A. All plant material will conform to the current issue of the American Standard for Nursery Stock, published by AmericanHort (formerly ANLA).

B. Plant material must be selected from nurseries that have been inspected and certified by state plant inspectors.

C. Collected material may be used when approved by Director’s Representative and owner’s representative.

D. Nomenclature will be in accordance with *Hortus III*, by L.H. Bailey.

1.3 DEFINITIONS

A. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI

Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.

B. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

C. Landscape Plugs: Herbaceous plugs specifically designed to be planted directly in the ground. Healthy, vigorous, fully rooted herbaceous plants grown in trays. Plug sizes shall be a minimum of 2 inches x 2 inches wide and 3 to 5 inches deep. Do not use trays of more than 50 plants per tray.

1.4 SUBMITTALS

A. Quality Control Submittals:

1. Installer Qualifications: Contact information for 5 projects of similar scope within the last 5 years.
2. Worker's Qualifications Data: Names and addresses of 5 similar projects that each person has worked on during the past 2 years.

B. Planting Schedule: Submit proposed schedule to Director's Representative for approving, substituting, ordering, and installing plants. Include description of where and how plants will be stored between deliveries and installation on site. Include schedule for pre-installation conference at project site with owner's representative and Director's Representative.

C. Pre-bid Plant Lists: Contractor shall state the total number of each plant with the contract price. Submit plant lists to Director's Representative to review for compliance with planting plan and plant list.

D. Substitutions, Pre-Bid: Contractor shall make every reasonable effort to find the material specified. Contractor is responsible for qualifying his/her proposal to document any plant suitability or availability problems. If after extensive searching plant is not available, contractor shall offer substitutions to the Director's Representative for his/her consideration. Submit substitution requests at least three weeks prior to plant installation.

E. Photographs: Submit photographs of all trees and shrubs, as requested by the Director's Representative. Photographs shall include a person (or a clearly-marked measuring rod next to plants) for scale. Photographs shall exhibit the size, growth habit, and general visual quality of plants. Photographs of dense clusters of plants, in which one plant is not distinguishable from another, are not acceptable. Digital photographs submitted via email are acceptable.

F. Substitutions, Post-bid: Contractor shall make every effort to eliminate post-bid substitutions. However, in the event the contract material has become unavailable, submit proposed substitutions to the Director's Representative for approval.

G. Nursery Order Plant Lists: Submit plant lists for final orders to Landscape Architect from each nursery ordered. Show price clarifications for all recommended substitutions.

H. Product Certificates: For each type of manufactured product signed by product manufacturer.

I. Retain below if Owner's personnel will provide maintenance after exterior plants are established and if Contractor's recommendations will be sought. Delete if not required.

J. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time, English-speaking, supervisor on Project site when exterior planting and regular maintenance is in progress.

B. Worker's Qualifications: The persons performing the planting and their supervisor shall be personally experienced in the planting and caring of plant material and shall have been regularly employed by a company engaged in the planting and caring of plant material for a minimum of 2 years.

C. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

D. Observation: Director's Representative/Landscape Architect may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Director's Representative/Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, 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. Notify Director's Representative of sources of planting materials seven days in advance of delivery to site.

1. Notify Director's Representative and Landscape Architect of sources of planting materials seven days in advance of delivery to site.

E. Preinstallation Conference: Conduct conference at Project site with Landscape Architect and Director's Representative. Discuss overall schedule, plant procurement, delivery and storage, installation, and coordination with other trades. Provide meeting minutes of decisions made.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store, irrigate, maintain, and otherwise protect balled and burlapped trees in a manner that prevents mechanical injury and physiological stress between the time of digging and delivery.

B. Deliver exterior plants freshly dug. Do not stockpile plants on site for more than 48 hours. Deliver plants only after preparations for planting have been completed and install immediately. Only deliver plants to the site that can be planted that day. If planting is delayed more than six hours after delivery, set plants in shade and protect from weather and mechanical damage. Keep all plants irrigated and roots moist.

C. Do not prune trees and shrubs before delivery, except as approved by Director's Representative or Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Irrigate balled and burlapped plants thoroughly immediately prior to transport. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

D. Handle planting stock by root ball. Planting stock with cracked or broken root balls will not be accepted.

E. Do not remove container-grown stock from containers before time of planting.

F. Thoroughly water plants stored on-site. Fully soak each container until water flows out of drain holes. Water as often as necessary to maintain root systems in a moist condition.

1.7 WORKMANSHIP

A. During delivery and installation, contractor shall perform in a professional manner, coordinating his/her activities so as not to interfere unduly with the work of other trades, and leaving his/her work area(s) clean of litter and debris at the close of each workday.

B. During planting, all areas shall be kept neat and clean, and precautions shall be taken to avoid damage to existing and newly installed plants, trees, and structures.

C. Upon completion, all debris and waste material resulting from planting operations shall be removed from the project and the area cleaned up.

D. Any damaged areas caused by the contractor shall be restored to their original condition.

1.8 COORDINATION

A. Contractor is responsible for determining plant quantities per planting plan. Contractor is responsible for filling all areas on plans shown to be planted on planting plan. Contractor shall prepare his or her own quantity list from the plan(s). All ground cover beds are to be filled at the specified spacing. Seeding is to be done at the rate specified by the seed provider to establish full coverage of the areas on the plans.

B. 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: March 15 to May 15

    a. Quercus species
    b. Deciduous material
    c. Herbaceous material other than seeds

2. Fall Planting: September 6 to October 15

    a. Evergreen material
    b. Deciduous material other than Quercus spp.
    c. Herbaceous material other than seeds

3. Seed Planting: See Section 329220 “Herbaceous Seeding”
4. No Planting shall occur between May 15 and September 5, inclusive, except seeds (see Section 329220 “Herbaceous Seeding”, or as authorized by the Director’s Representative.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

D. Coordination with Other Work: Coordinate planting with all other work of the project.

E. Delete below if no lawns, or revise if contrary to planting schedule.

F. Coordination with Lawns and Seeded Areas: Plant trees and shrubs after finish grades are established and before planting lawns or seeded areas, unless otherwise acceptable to Director’s Representative.

1. When planting trees and shrubs after lawns or seeded areas, protect lawn and seeded areas and promptly repair damage caused by planting operations.

1.9 WARRANTY

A. When warranties are required, verify with Owner's counsel that special warranties stated in this Article are not less than remedies available to Owner under prevailing local laws. Coordinate with Division 1 Section "Product Requirements."

B. Contractor shall provide a warranty on plant materials for a two-year period commencing on the date of initial acceptance. All plants shall be alive and in satisfactory health at the end of the guarantee period.

C. Any material that is 15% dead or more shall be considered dead and must be replaced at no charge. A tree shall be considered dead when the main leader has died back or 15% or more of the crown is dead.

D. Remove dead plants immediately.

E. Perennials and grasses shall be guaranteed for two years after initial acceptance.

F. Replacements shall be made during the next planting season.

G. Replacements shall be of the same type, size, and quality as original species unless otherwise negotiated.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish nursery-grown trees and shrubs in accordance with good horticultural practices under climatic conditions similar to those of the Project for at least two years, unless specifically noted otherwise. All plant materials shall come from a 200-mile radius of the project site. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, leaf spotting, injuries, abrasions, and disfigurement.

2.2 TREES

A. Trees shall be planted such that the root flare is 1" above adjacent grade, unless the drawings indicate otherwise. Tree planting height shall be dictated by the actual root flare rather than the top of rootball as received from growers or nurseries.

1. Tops of tree rootballs shall be no higher than 2" above the tops of main order tree roots.
2. If main order roots are buried greater than 2" but less than 4" below the top of tree rootballs, contractor must trim rootballs by carefully removing soil from the top of the rootballs so that main order roots are within 2" of the top of rootball.
3. If main order roots are buried greater than 4" below the top of rootball, the tree will be rejected, and the contractor must remove the tree from the jobsite.
4. The contractor is responsible for ensuring that trees received on site and planted on site meet the aforementioned specifications regarding tree root flare and rootball. The contractor is responsible for ensuring that the landscape architect has an opportunity to review the tree root flares of trees in the growers' field or nursery yard. **If tree root flares are obscured (due to trunk wrap or burlap or other obstructions), landscape architect's acceptance of trees in the grower's yard or nursery shall constitute acceptance of trees WITH THE EXCEPTION of trees whose root flare is buried**

greater than 4" below top of rootball. In the event that contractor does not allow Landscape Architect to visually observe tree root flares during tree selection at grower's yard or nursery, Landscape Architect reserves the right to reject any tree delivered to the site if tree's root flare is buried greater than 4" below top of rootball, even if Landscape Architect previously accepted said trees at the grower's yard or nursery.

B. Grade: Provide trees and shrubs of sizes and grades complying with ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Label each tree and shrub with a securely attached, waterproof tag bearing legible designation of botanical and common name.

D. If formal arrangements or consecutive order of trees or shrubs is shown, select stock for uniform height, branching height, and spread, and number label to assure symmetry in planting.

2.3 SHADE AND FLOWERING TREES

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.

1. Provide balled and burlapped trees except as noted on the Plant Schedule.
2. Branching Height: One-third to one-half of tree height.

B. Multi-stem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:

1. Stem Form: Clump.
2. Provide container-grown trees.

2.4 DECIDUOUS SHRUBS

A. Fully-branches plants with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub. Avoid plants that have been in containers too long and have excessive circling or girdling roots. Plants must be hardened-off outside of greenhouse setting in full sun conditions for at least three weeks prior to delivery.

1. Provide balled and potted or container-grown shrubs as indicated in the Plant Schedule in the drawings.

2.5 CONIFEROUS EVERGREENS

A. Specimen-quality, exceptionally heavy, densely branched, symmetrically shaped coniferous evergreens, complying with ANSI Z760.1. Needles should exhibit no brown tips or dead

branches. Trees shall be balled and burlapped from soil which will hold a natural ball. Manufactured balls are unacceptable.

2.6 GROUND COVER PLANTS

A. Ground Cover: Provide ground cover of species indicated, established and well rooted in pots or similar containers, and complying with ANSI Z60.1 and the following requirements:

1. Provide Container grown or plugs as indicated in the Plant Schedule.
2. For species where seed is indicated, see Section 329220 “Herbaceous Seeding"

2.7 PLANTS

A. Woody Vines:

1. Provide vines of species indicated, and size indicated, complying with requirements of ANSI 12.1.3 and 12.6.

2.8 PLANTING SOIL

A. Reference Section 329115 “Soil Preparation (Performance Specification).”

2.9 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood.

2.10 STAKES AND GUYS

A. Install Stakes and Guys per methods and locations as shown on the Drawings.

B. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches (50 by 50 mm) by length indicated, pointed at one end.

C. Guy and Anchoring System:

1. ArborGuy 40E (www.stakingsystems.com), or approved equivalent.
2. ArborTie: Flat woven polypropylene (ArborTie Green). https://www.deeproot.com/resources/arbortie/ArborTieTechSheet.pdf , or approved equivalent.

D. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

2.11 MISCELLANEOUS PRODUCTS

A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs, designed to permit transpiration but retard excessive loss of moisture from plants. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

1. Dowax by Dow Chemical Co., or Wilt-Proof by Nursery Specialty Products, Inc.

B. Tree Watering Bags: UV-treated polyethylene irrigation bag reinforced with nylon webbing. All sides to be watertight with ¼" thick heat seals. Bags shall have nylon zippers to allow to be secured to tree or secured to other bags for multiple-bag configuration.

1. Manufacturer: TreeGator, 1-866-873-3428, or approved equivalent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance. Notify Director's Representative, in writing, of any conditions that might prevent satisfactory completion. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Test drainage of pits and planting beds. Notify Director's Representative, in writing, of potential poor drainage of tree and shrub pits and planting beds. Recommend a program for correction of poor drainage conditions and submit proposal to Director's Representative and Landscape Architect. Do not proceed with planting operations in areas of poor drainage until conditions are corrected, or direction is given by the Director's Representative.

3.2 PREPARATION

A. Protect existing plant material and lawns, as well as structures, utilities, sidewalks, pavements, and other facilities from damage caused by planting operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple exterior plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before planting. Make minor adjustments as required.

D. Lay out exterior plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

E. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

3.3 PLANTING BED ESTABLISHMENT

A. Section 329115 “Soil Preparation (Performance Specification)”.

3.4 TREE AND SHRUB EXCAVATION

A. Section 329115 “Soil Preparation (Performance Specification)”.

3.5 TREE AND SHRUB PLANTING

A. Set balled and burlapped stock plumb and in center of pit or trench with root flare 1 inch (25 mm) above adjacent finish grades.

1. Cut burlap and wire baskets from top half of root balls, but do not remove from under root balls. Discard removed burlap and wire baskets; do not turn down baskets and leave in tree or shrub pits. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, install transplant inoculants per manufacturer’s directions and water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.
3. Prepare surface of planting bed as shown on drawings.

B. Set container-grown stock plumb and in center of pit or trench with root flare 1 inch (25 mm) above adjacent finish grades.

1. Carefully remove root ball from container without damaging root ball or plant.
2. Make four (4) evenly spaced vertical cuts in the sides of the root ball with a clean, sharp utility knife. Cuts are to be one inch (1”) deep and are to extend the full height of the rootball.
3. Water plants thoroughly or soak them in a wheelbarrow filled with water prior to being planted. Plants should be installed with sopping wet rootballs.
4. Place planting soil mix around rootball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, install transplant inoculants per manufacturer’s directions and water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.
5. Prepare surface of planting bed as shown on drawings.

C. Organic Mulching: Apply 2-inch (50-mm) average thickness of organic mulch extending 12 inches (300 mm) beyond edge of planting pit or trench. Do not place mulch within 3 inches (75 mm) of trunks or stems.

3.6 GUYING AND STAKING

A. Guy and Stake trees as indicated in the drawings. Installation of tree support systems shall be completed within 48 hours of planting, utilizing applicable methods as indicated.

3.7 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs only as directed by Project Arborist or Landscape Architect.

3.8 LANDSCAPE PLUG PLANTING

A. Perennial and Grass Landscape Plugs

1. Thoroughly soak the roots of all landscape plugs prior to layout. Roots should be dripping wet when they go into the ground.
2. Using a hand trowel, dibble, small spade or gas-powered auger fitted with a 3” diameter drill, install landscape plugs into soil. Make hole deep enough to accommodate roots without bending.
3. Backfill with soil. Press soil around the rootball firmly by hand to eliminate any air pockets.
4. After each 50’x50’ area planted, water newly installed plants with a hose. Use a high pressure setting and water each plug thoroughly, using a high velocity stream to eliminate any air pockets created during installation.

3.9 SEEDING

A. See Section 329220 ”Herbaceous Seeding”.

3.10 GROUND COVER AND VINE PLANTING

A. Set out and space ground cover and plants as indicated.

B. Dig holes large enough to allow spreading of roots and backfill with planting soil.

C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

E. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.11 PLANTING BED MULCHING

A. Mulch backfilled surfaces of planting beds and other areas indicated.

1. Organic Mulch: Apply 2-inch (50-mm) average thickness of organic mulch, and finish level with adjacent finish grades. Do not place mulch against plant stems.

3.12 TREE WATERING BAGS

A. Install a minimum of one tree watering bag per tree. Install multiple bags for trees as recommended by the tree watering bag manufacturer. Fill water bags for each tree.

3.13 INITIAL ACCEPTANCE

A. When all work except maintenance and guarantee program of this contract has been completed, Landscape Architect/Director's Representative will perform a Substantial Completion inspection. Provide notification at least ten (10) working days before inspection date.

1. If required, a "punch list" of items to be completed by an agreed upon date will be issued by the Landscape Architect/Director's Representative after the Substantial Completion inspection.

B. Work will be considered Substantially Complete after all "punch list" items are complete. Notify the Landscape Architect at least five (5) working days before re-inspection date, to verify completion of the "punch list" items.

C. Substantial Completion certificate will be issued and dated by the Landscape Architect following the "punch list" verification inspection.

3.14 MAINTENANCE

A. Maintain all exterior plants covered by this Section, as required to establish healthy, viable plantings, including the following maintenance requirements during the maintenance period indicated in Part 1 of this Section:

1. Mowing;
2. Edging;
3. Pruning;
4. Cultivating;
5. Watering, including filling tree water bags, do not allow plants to wilt at any time;
6. Weeding;
7. Fertilizing;
8. Mulching;

9. Maintaining trees support systems at correct tension;
10. Resetting plants to proper grade and vertical position;
11. Insect and Pest Control as required to keep plants free of insects and disease;
12. Removal of trash and debris; and
13. Replacing dead or dying plants.

3.15 FINAL ACCEPTANCE

A. Inspection to determine Final Acceptance of planted areas will be made by the Landscape Architect upon Contractor's request at completion of the two-year Warranty Period. Provide notification at least fifteen (15) working days before requested inspection date.

1. Planted areas will be acceptable provided all requirements, including plant replacements and maintenance, have been complied with and healthy, thriving, and growing plants are established.
2. Remove all Tree Staking and Guying materials prior to Final Acceptance inspection.
3. Knock down, regrade, and re-mulch all tree pit saucers prior to Final Acceptance inspection.

3.16 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

END OF SECTION 329300

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SECTION 329600 - TRANSPLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes transplanting non-nursery-grown fruit trees by tree spade.

B. The trees to be transplanted are heritage cultivars.

1. Apples:

a. Esopus spitzenburg
b. Rhode Island greening
c. Yellow Newtown pippin

2. Pears: Pyrus communis dwarf ‘potomac’

C. Related Requirements:

1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 329300 "Exterior Plants" for new trees from nursery-grown sources.

1.2 DEFINITIONS

A. Biochar: A solid material obtained from the carbonization thermochemical conversion of biomass in an oxygen-limited environments.

B. Caliper: Diameter of a trunk as measured by a diameter tape or the average of the smallest and largest diameters at a height 6 inches (150 mm) above the root flair for trees up to, and including, 4-inch (100-mm) size at this height; and as measured at a height of 12 inches (300 mm) above the root flair for trees larger than 4-inch (100-mm) size.

C. Endomycorrhizae: Endomycorrhizal fungi is one of the major types of known mycorrhizae which differs from the another type of mycorrhizae, ectomycorrhizae, in structure. This makes for a more invasive symbiotic relationship between the fungi and the plant which creates a greater contact surface area facilitating a greater transfer of nutrients between the two

D. Root-Ball Depth: Measured from bottom of trunk flare to the bottom of root ball.

E. Root-Ball Width: Measured horizontally across the root ball with an approximately circular form or the least dimension for non-round root balls, not necessarily centered on the tree trunk**,** but within tolerance according to ANSI Z60.1.

F. Root Flare: Also called "trunk flare." The area at the base of the tree'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.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to transplanting work include, but are not limited to, the following:

    a. Mapping of trees to be transplanted and the locations of the reinstallation for each.
    b. Construction schedule. Verify availability of materials, personnel, equipment, and unimpeded access needed to make progress and avoid delays.
    c. Tree and plant protection.
    d. Tree maintenance.
    e. Arborist's responsibilities.

1.4 ACTION SUBMITTALS

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

1. Root Stimulant
2. Biochar

B. Mapping of trees to be removed and their new locations by tree.

C. Pruning Schedule: Written schedule prepared by arborist detailing scope and extent of pruning each tree in preparation for and subsequent to transplanting.

1. Species and size of plant.
2. Location on site plan. Include unique identifier for each.
3. Reason for pruning.
4. Seasonal limitations on pruning.
5. Preparatory Pruning: Time schedule and description of preparatory pruning to be performed.

    a. Indicate time in months preceding the extraction of the tree.
    b. Indicate diameter of root ball and depth of root pruning for each tree.

6. Description of root and crown pruning during and subsequent to transplanting.
7. Description of maintenance following pruning.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified tree-service firm and arborist.

B. Certification: From arborist, certifying that transplanted trees have been protected during construction and that trees were promptly and properly treated and repaired when damaged.

C. Maintenance Recommendations: From arborist, recommended procedures to be established by Owner for care and protection of trees after completing the Work.

1. Submit before completing the Work.

D. Existing Conditions: Documentation of existing trees indicated to be transplanted, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.

1. Use sufficiently detailed color photographs or video recordings. Color shall accurately depict hue condition of foliage and bark.
2. Include drawings and notations to indicate specific wounds and damage conditions of each tree designated to be transplanted.

E. Tree-Transplanting Program: Submit before work begins.

F. Sample Warranties: For special warranties.

G. Tree-maintenance reports.

1.6 QUALITY ASSURANCE

A. Tree-Service Firm Qualifications: An experienced landscaping contractor or tree-moving firm that has successfully completed transplanting work of fruit trees similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.

1. Arborist Qualifications: Certified Arborist as certified by ISA.

B. Tree-Transplanting Program: Prepare a written plan by arborist for transplanting trees for the whole Project, including each phase or process, tree maintenance, and protection of surrounding materials during operations. Describe in detail the materials, methods, and equipment to be used for each phase of the transplanting work.

1. Include transplanting times appropriate for each species at the Project location unless otherwise indicated on Drawings or directed by arborist. No trees will be transplanted out of Season. Trees to be transplanted early 2025 with the approval of the Director's Representative and when weather and temperature permit.
2. Include a transplanting schedule for each species to be transplanted, coordinated with the Project schedule.
3. Proposed dosing and delivery of biochar and endomycorrhizae.
4. Include site plans clearly marked to show tree-moving routes from extraction to planting locations. Indicate proposed equipment, weight, and turning radii.
5. Show details of temporary protective barriers where needed.
6. Include diagrams showing clearances to utility lines and other encumbrances along route.
7. Include care and maintenance provisions and eventual removal of tree stabilization.

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 trees.
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 with appropriate certificates.

C. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy their natural shape.

D. Completely cover foliage when transporting trees while they are in foliage.

E. Handle trees by root ball. Do not drop trees. Do not pierce the root ball.

F. Move trees after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after moving, set trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist. The time limitation from digging, removing, transporting, to installing transplanted plant material must be the same day. The time limitation between installing the plant material and placing the mulch must be a maximum 48 hours. If project conditions prevent the Contractor from transplanting and installing plant material on the same day, plant materials must be boxed or heeled in as required. Plant material must be maintained and protected by the Contractor.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify final grade elevations and final locations of trees and construction contiguous with trees by field measurements before proceeding with transplanting work. Perform transplanting only after finish grades are established.

B. Seasonal Restrictions: Transplant trees during appropriate in-season periods in accordance with Arborist’s recommendations.

C. Weather Limitations: Proceed with transplanting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Do not transplant during excessively wet or frozen conditions. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

D. Coordination with Turf Areas (Lawns): Perform transplanting before planting turf areas unless otherwise indicated.

1. When transplanting after planting turf areas, protect turf areas, and promptly repair damage caused by transplanting operations.

E. Coordination with Planting Beds: Perform transplanting before planting bedded areas unless otherwise indicated.

1. When transplanting after planting bedded areas, protect bedding plants, and promptly repair damage caused by transplanting operations.

1.9 WARRANTY

A. Installer's Special Warranty: Tree-service firm agrees to repair or replace trees and related materials that fail 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. Death and unsatisfactory growth is defined as more than 15 percent dead or in an unhealthy condition or failure to meet general performance requirements at end of warranty period.
c. Structural failures including trees falling or blowing over.
d. Faulty performance of materials and devices related to tree plantings including tree stabilization and watering devices.

2. The Landscape Architect will be the sole determiner of failure of the transplant.

3. Warranty Periods from Date of Transplanting Completion

a. Trees: **24** months.

4. Include the following remedial actions as a minimum:

a. Remove dead trees and trees with unsatisfactory growth at end of warranty period; replace with a tree of the same cultivar when directed.
b. A limit of one replacement of each tree will be required except for losses or replacements due to failure to comply with requirements.
c. Replace materials and devices related to tree plantings.
d. Provide extended warranty for period equal to original warranty period, for replaced trees.

1.10 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide tree maintenance by skilled employees of tree-service firm and as required in Part 3. Begin maintenance immediately after **preparatory pruning** and continue until plantings are healthy and well established but for not less than maintenance period below.

1. Maintenance Period: **24** months from date of transplanting completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Transplanted trees shall be healthy and resume vigorous growth within **one year** of transplanting without dieback due to defective extracting, handling, planting, maintenance, or other defects in the Work.

2.2 PLANTING MATERIALS

A. Backfill Soil: Excavated soil mixed with planting soil of suitable moisture content and granular texture for placing and compacting in planting pit around tree, and free of stones, roots, plants, sod, hard 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.

1. Mixture: Well-blended mix of two parts excavated soil to one part planting soil.
2. Planting Soil: Planting soil Shall be a sandy/loam, friable soil that has been removed to a depth of one foot (1') or less, if subsoil is encountered. Topsoil shall be of uniform quality, free from hard clods, stiff clay, hard pan, sods, partially disintegrated stone, lime, cement, ashes, slag, concrete, tar residues, tarred paper boards, chips, sticks, or any other undesirable material. No topsoil shall be delivered in a frozen or muddy condition.

2.3 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood**,** free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
2. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood preservative treatment by pressure process.
3. Flexible Ties: Wide rubber or elastic bands or straps.
4. Guys and Tie Wires: ASTM A641/A641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.
5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
6. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.
7. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by tree stem; sized as indicated and according to manufacturer's written instructions.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following]:

        1) Anchor Tie Down Systems, Inc.; Twister Tie Down.
        2) Arborbrace; Arborbrace Tree Guying System.
        3) Deep Root Partners, L.P.; ArborTie.
        4) J. R. Partners; R2 Stake, Mega Stake, or U-Stake System.

B. Root-Ball-Stabilization Materials:

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 (38-by-38-mm actual) by length indicated; stakes pointed at one end.
2. Wood Screws: Hot-dip galvanized or stainless steel.
3. Proprietary Root-Ball-Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball; sized according to manufacturer's written instructions unless otherwise indicated.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    b. that may be incorporated into the Work include, but are not limited to, the following:

        1) Border Concepts, Inc.; Tomahawk Tree Stabilizers.
        2) Foresight Products, LLC; Duckbill Rootball Fixing System.
        3) Tree Staple, Inc.; Tree Staples.

2.4 WATERING DEVICES

A. Slow-Release Watering Device: Standard product manufactured for drip-irrigation of plants and emptying its water contents over a period of 5 to 9 hours; manufactured from UV-light stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2. th requirements, products that may be incorporated into the Work include, but are not limited to, the following:

    a. Spectrum Products, Inc.; Treegator Original
    b. Turf Chemicals Plus, Inc.; Tree Ring Regular

2.5 MISCELLANEOUS PRODUCTS

A. Organic Mulch: Shredded bark mulch.

B. Burlap: Non-synthetic, biodegradable.

C. Mycorrhizal Fungi: Endomycorrhizae for pear and apple trees.

D. Biochar

1. Shall be derived from untreated plant material and heated to a temperature no less than 600 degrees Fahrenheit. Biochar may not be exposed to oxygen during pyrolysis. Biochar should be ground into small, sub-millimeter particles of a uniform grade with no additives or any other treatment. The Biochar shall be free of soil, plant material (roots,

brush, weeds), stones, lumps, or similar objects larger than two inches (2") in greatest diameter.

2. All biochar shall be delivered in standard two (2) cubic yard size bags of the manufacturer, showing weight, analysis, and name of manufacturer. It shall be stored as directed by the Engineer in such a manner that its effectiveness will not be impaired.
3. Biochar shall be provided by Seneca Farms, Ithaca, NY (https://sfbiochar.com/) or Saratoga Biochar, Saratoga, NY (https://saratogabiochar.com/), or approved equal.

E. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch (25-mm) sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent dry weight.

F. Fertilizer: No synthetic fertilizer may be used.

PART 3 - EXECUTION

3.1 PRE-TRANSPLANTING SPECIALIST WORK

A. Pre transplanting work will be done before the start of this contract and will be performed by others.

3.2 EXAMINATION

A. Erosion and Sedimentation Control: Examine the site to verify that temporary erosion- and sedimentation-control measures are in place. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross transplanting areas.

B. For the record, prepare written report, endorsed by arborist, listing conditions detrimental to transplanting work and tree protection and health and any work done to the trees before or during the transplant process.

C. Proceed with transplanting only after unsatisfactory conditions have been corrected.

3.3 CROWN PRUNING

A. Crown pruning shall be done only as directed by the Project Arborist.

3.4 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, other facilities, turf areas, and other plants and planting areas from damage caused by transplanting operations.

B. Utility Locator Service: Notify utility locator service for area where Project is located before beginning excavation.

C. Locate and clearly identify trees for transplanting. Tie a 1-inch (25-mm) blue-vinyl tape around each tree at 54 inches (1372 mm) above the ground.

D. Lay out individual transplant locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before transplanting. Make minor adjustments as required.

E. Apply antidesiccant to trees uniformly, using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during extracting, handling, and transportation.

1. If deciduous trees are moved in full leaf, spray with antidesiccant before extracting and again two weeks after transplanting.

F. Wrap trees with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during extracting, handling, and transporting.

3.5 EXCAVATION AND PLANTING EQUIPMENT

A. Tree Spade: Track-mounted mechanized tree mover; sized according to manufacturer's size recommendation for each tree being transplanted.

B. Hand excavation.

3.6 EXCAVATING PLANTING PITS

A. General: Excavate under supervision of the arborist.

1. Excavate planting pits or trenches with sides sloping. 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. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as root ball.
3. Keep excavations covered or otherwise protected until replanting trees.

B. Subsoil and topsoil removed from excavations **may** be used as planting soil.

C. Obstructions: Notify Director’s Representative if unexpected rock or obstructions detrimental to trees are encountered in excavations.

1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.

D. Seepage: Notify Director’s Representative if subsoil conditions evidence unexpected water seepage into tree-planting pits.

E. Drainage: Fill planting pit or trench with 10 inches of water and time the infiltration rate of the soil. If the drainage rate is less than 0.25 inch per hour, notify Director’s Representative to determine need for subsurface drainage.

3.7 EXTRACTING TREES

A. General: Extract trees under supervision of the arborist.

B. Orientation Marking: Mark the north side of each tree with non-permanent paint before extracting.

C. Root-Ball Width: Minimum 10 inches (250 mm) of root-ball diameter, or least dimension for non-round root balls, for each inch (25 mm) of tree caliper being transplanted.

D. Root-Ball Depth: As determined by the arborist for each species and size of tree and for site conditions at original and planting locations.

E. Digging:

1. Dig and clear a pit with tree spade to the depth of the root system. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
2. Use narrow-tine spading forks to comb soil to expose roots with minimal damage to root system.
3. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking.
4. Cut exposed roots manually with clean, sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not paint or apply sealants on cut root ends.
5. Temporarily support and protect exposed roots from damage until they are permanently redirected and covered with soil. Cover roots with burlap and keep them moist until planted.

F. Extracting with Tree Spade: Use the same tree spade to extract the tree as will be used to transport and plant the tree.

1. Do not use tree spade to move trees larger than the manufacturer's maximum size recommendation for the tree spade being used.
2. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

3.8 PLANTING

A. Planting Standard: Perform planting according to ANSI A300 (Part 6) unless otherwise indicated.

B. Before planting, verify that root flare is visible at top of root ball. 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.

C. Ensure that 1inch of the root flare is visible after planting.

D. Remove injured roots by cutting cleanly with a clean, sharp, pruning instruments; do not break. Do not paint or apply sealants on cut root ends.

E. Orientation: Position the tree so that its north side, marked before extracting, is facing north in its new location.

F. Set tree plumb and in center of planting pit with **top** of root flare 1 inch above adjacent finish grades.

1. Use specified backfill soil for backfill.
2. If the area under the tree was initially dug too deep, add backfill to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
3. After placing some backfill around root ball to stabilize plant, begin backfilling.
4. 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.
5. Redirect exposed root ends downward in backfill areas where possible. Hand-expose roots as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately 3 inches back from new construction and as required for root pruning.
6. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended by arborist. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
7. Continue backfilling process. Water again after placing and tamping the final layer of soil.

G. Planting with Tree Spade: Use the same tree spade for planting as was used to extract and transport the tree. Do not use tree spade for trees larger than the manufacturer's maximum size recommendation for the tree spade being used.

H. Slopes:

1. Before excavating the tree, mark the downhill side. Plant the tree in the new location with the same orientation.
2. When planting on slopes, set the tree so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.9 CROWN PRUNING

A. Do not prune branches pre-transplant and prune only as approved by the Landscape Architect and directed by arborist.

1. Prune to remove only injured, broken, dying, or dead branches. Do not prune for shape.
2. Do not remove or reduce living branches to compensate for root loss caused by cutting root system or to improve natural tree form.
3. Pruning Standards: Perform pruning according to ANSI A300 (Part 1).

B. Unless otherwise directed by arborist and acceptable to Landscape Architect, do not cut tree leaders.

C. Cut branches with clean, sharp pruning instruments; do not break or chop.

D. Do not paint or apply sealants to wounds.

E. Provide subsequent maintenance during Contract period as recommended by arborist.

F. Chip removed branches and as directed by the Director's Representative.

3.10 TREE STABILIZATION

A. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings or directed by arborist.

1. Site-Fabricated Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree per the drawings.

    a. Securely attach guys to stakes per drawings. Adjust spacing to avoid penetrating root balls or root masses. Provide compression spring for each guy wire and tighten securely.
    b. Support trees with guywire, connected hose chafing guard at contact points with tree trunk and reaching to a compression spring. Allow enough slack to avoid rigid restraint of tree.
    c. Attach flags to each guy wire, 30 inches (760 mm) above finish grade.

2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.11 MULCHING

A. Organic Mulch: Apply 2 to 3-inch average thickness of organic mulch as indicated on the Drawings and finish level with adjacent finish grades. Do not place mulch within 3 inches of trunks or stems.

3.12 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree and fill with water according to manufacturer's written instructions.

3.13 TREE MAINTENANCE

A. Perform tree maintenance as recommended by arborist. Maintain arborist observation of transplanting work.

B. Maintain trees 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. Treat as required to keep trees free of insects and disease.

C. From time of preparatory root pruning measure soil moisture adjacent to edge of each root ball weekly. Record findings and weather conditions.

D. Fill areas of soil subsidence with backfill soil. Replenish mulch materials damaged or lost in areas of subsidence.

E. Apply treatments approved by the arborist as required to keep tree materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

F. Pesticide Application: If approved by the arborist, apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

1. Pre-Emergent Herbicides (Selective and Non-Selective): Apply in accordance with manufacturer's written instructions. Do not apply to seeded areas.
2. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written instructions.

G. Reports: Have arborist prepare monthly inspection reports.

3.14 REPAIR AND REPLACEMENT

A. General: Repair or replace transplanted trees and other plants indicated to remain or be relocated that are damaged by construction operations, in a manner recommended by the arborist and approved by Director’s Representative.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours according to arborist's written instructions.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 15 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern. The Project Arborist will be the sole determiner of tree condition.

1. Provide new trees of same size as those being replaced for each tree of 4 inches or smaller in caliper size.
2. Provide one year additional maintenance and warranty on replacement trees.
3. Species of Replacement Trees: Same species and variety as the tree being replaced.

3.15 CLEANUP AND PROTECTION

A. During transplanting, keep adjacent paving and construction clean and work area in an orderly condition.

B. Protect trees from damage due to transplanting operations and operations of other contractors and trades. Maintain protection during transplanting and maintenance periods. Treat, repair, or replace damaged plantings.

C. After planting and before Substantial Completion, remove tags, markings, tie tape, labels, wire, burlap, and other debris from transplanted trees, planting areas, and Project site.

3.16 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Transport surplus satisfactory soil to designated storage areas on project site. Stockpile or spread soil as directed by Director's Representative.

1. Except for materials indicated to be retained on project site or recycled, remove excess excavated material, waste materials, displaced plants, trash, and debris, and legally dispose of them off project site.

END OF SECTION 329600

SECTION 330500 – COMMON WORK RESULTS FOR UTILITIES

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the installation of buried piping.

1.2 REFERENCES

A. The following references shall be applicable:American Society of Testing and Materials (ASTM).
   1. American National Standards Institute (ANSI).
   2. American Water Works Association (AWWA).
   3. Uni-Bell Plastic Pipe Association.

1.3 SUBMITTALS

A. Submit for approval a schedule for all proposed testing. Include proposed testing procedures indicating the sequence in which pipe sections will be tested and description of methods and equipment to be used.

B. Field Test Reports: Submit results of field testing directly to Engineer with copy to Contractor.

1.4 STORAGE, AND HANDLING

A. Deliver and store materials within the Contract limits as approved by Engineer.

B. Handle materials carefully with approved handling devices in accordance with manufacturer's recommendations. Special care shall be exercised during delivery and storage to avoid damage to the materials.

C. Do not drop or roll products off trucks. Products are not to be otherwise dragged, rolled, or skidded.

D. Materials shall be stored on heavy wood blocking or platforms in accordance with the manufacturer's instructions and recommendations. Materials shall not be in contact with the ground and their interiors shall be maintained free from dirt and other foreign matter.

E. Products cracked, gouged, chipped, dented, or otherwise damaged will not be approved and are to be removed and replaced at the Contractor's expense, unless the product can be repaired in a manner acceptable to the manufacturer and the Engineer. All repairs shall be at the Contractor's expense.

1.5 COORDINATION

A. Contractor shall be responsible for coordinating site utility work with other trades to ensure building service connection locations are verified and coordinated prior to commencing site construction.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Conform to individual pipe specification(s).

B. Pipe transition fittings: Shall be as indicated on the drawings. If not specifically indicated selection shall be based on pressure requirements of the system and types of materials being joined. Product selection shall be approved by the engineer.

C. Grout:
   1. Description: ASTM C1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
      a. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
      b. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
      c. Packaging: Premixed and factory packaged.

D. Flowable Fill:
   1. Description: Low-strength-concrete, flowable-slurry mix.
      a. Cement: ASTM C150, Type I, Portland.
      b. Density: 115 to 145 pounds/cubic foot (1840 to 2325 kg/cu. m) .
      c. Aggregates: ASTM C33, natural sand, fine and crushed gravel or stone, coarse.
      d. Aggregates: ASTM C33, natural sand, fine.
      e. Admixture: ASTM C618, fly-ash mineral.
      f. Water: Comply with ASTM C94/C94M.
      g. Strength: Greater than 40 psig at 28 days and no more than 150 psig at one year.

PART 3 – EXECUTION

3.1 UTILITY DEMOLITION

A. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

3.2 BURIED PIPE INSTALLATION

A. General:

1. Installation of all pipe, fittings, valves, specials, and appurtenances shall be subject to the review and/or approval of the Engineer.
2. Install piping valves and fittings as shown, specified and as recommended by the manufacturer and in conformance with referenced standards, and approved Shop Drawings.
3. Request instructions from Engineer before proceeding if there is a conflict between the manufacturer's recommendations and the Drawings or Specifications.
4. All piping and appurtenances shall be inspected by the Engineer prior to installation. Engineer's inspection will not relieve Contractor or manufacturer from responsibility for damaged products.
5. Present all conflicts between piping systems and equipment, structures or facilities to Engineer for determination of corrective measures before proceeding.
6. Take field measurements prior to installation to ensure proper fitting of Work. Uncover the existing pipelines sufficiently in advance of the proposed Work in order that the type and location of the existing pipes and joints and other information required to fabricate the proposed piping can be determined. Obtain whatever information is required to complete the connections of the proposed pipelines to the existing pipelines.
7. Carefully examine all piping for cracks, damage, or other defects before installation. Immediately remove defective materials from the site, unless the defective materials can be repaired in a manner acceptable to the manufacturer and Engineer. Remove, replace, or repair at the Contractor's expense piping found to be broken or defective.
8. Inspect interior of all piping and mating surfaces and remove all dirt, gravel, sand, debris, or other foreign material before installation. Maintain the interior of all piping clean until acceptance of the completed Work. Prevent foreign matter from entering joint space.
9. Install buried piping accurately to line and grade shown, specified or directed, unless otherwise approved by the Engineer. Use accurate means of determining and checking the alignment and grade subject to the approval of the Engineer. Remove and relay piping that is incorrectly installed at Contractor's expense.
10. Do not lay piping in water, unless approved by the Engineer. Ensure that the water level in the trench is at least 6 inches below the bottom of piping. Maintain a dry trench until jointing and backfilling are complete, unless otherwise specified in these Specifications or approved by the Engineer.
11. Pipe laying work shall be conducted so that trenching operations are not advanced too far ahead of the pipe laying operation resulting in excessive lengths of open trench. In general, open trench ahead of pipe laying shall not exceed 50 feet.
12. Start laying piping at lowest point and proceed toward the higher elevations, unless otherwise approved by the Engineer. Slope piping uniformly between elevations shown on the Drawings or as otherwise provided by the Engineer.

13. Where pipe crossings occur, the lower pipe shall be laid first and all backfill thoroughly compacted to the level of the higher pipe before the higher pipe is installed. Backfill material under such conditions may be earth, broken stone, or 2500 psi concrete.
14. Install piping so that the barrel of the piping and not the joints receives the bearing pressure from the trench bottom, or other bedding condition.
15. No piping shall be brought into position until the preceding length, valve, fitting, or special has been bedded and secured in place.
16. Whenever pipe laying is not actively in progress, the open ends of the piping shall be closed by a temporary plug or cap to prevent soil, water and other foreign matter from entering the piping.
17. Where required for inserting valves, fittings, special appurtenances, and closures, shall be made with a machine specially designed for cutting piping and in accordance with the manufacturer's instructions for field cutting of pipe. Make cuts carefully, without damage to piping, so as to leave a smooth end at right angles to the axis of the piping. Taper cut ends and file off sharp edges until smooth. Flame cutting will not be permitted. Replace and repair damaged piping.
18. Blocking under piping will not be permitted unless specifically approved by Engineer for special conditions.
19. Touch up protective and linings and coatings prior to installation.
20. Rotate piping to place outlets in proper position.

B. Bedding and Backfilling:
1. Bedded and installed piping in conformance with Section "Trenching and Backfilling" and as shown except as otherwise specified.
2. No piping shall be laid until Engineer approves the bedding condition.
3. Excavation in excess of that required as shown on the Drawings or specified, which is not authorized by the Engineer, shall be at the Contractor's expense. Backfilling and compaction of the over-excavated areas shall be at the Contractor's expense.
4. Carefully and thoroughly compact all pipe bedding and fill up to the pipe centerline with hand-held pneumatic compactors.

C. Transitions From One Type of Pipe to Another:
1. Provide all necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

D. Work Affecting Existing Piping:
1. Location of Existing Piping:
   a. Locations of existing piping shown shall be considered approximate. Contractor shall perform all necessary subsurface investigation to verify actual locations in the field.
   b. Determine exact location of existing piping to make connections, relocate, replace or which may be disturbed during earth moving operations, or which may be affected by work in any way.
   c. Coordinate all excavations with utility companies, Owner and Engineer.
2. Taking Existing Pipelines Out of Service:
   a. Do not take pipelines out of service unless specifically approved by Engineer.
   b. Notify Engineer at least 48 hours prior to taking any pipeline out of service.

3.3 SPECIFIC PIPE INSTALLATION

A. Polyvinyl Chloride Pipe (PVC):
   1. Gravity Sewers: Install all PVC piping in accordance with ASTM D2321 "Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications."
   2. Water Distribution/Pressure Sewers: Install all PVC pipe in accordance with AWWA Standard C605 "Underground Installation of PVC Pressure Pipe and Fittings for Water."
   3. Lay pipe with bell and spigot joints with bells upstream.
   4. Completely clean all jointing surfaces and adjacent areas prior to making joint.
   5. Field cut pipe for shorter than standard pipe lengths. Cut ends square and perpendicular to the pipe axis. Remove and smoothly bevel ends. Field spigots shall be stop marked with a felt tip mark or wax crayon for proper length of assembly insertion. The angle and depth of field bevels, and lengths to stop marks, shall be comparable in quality to factory made spigots.
   6. Assemble all joints in accordance with recommendations of the manufacturer. If a lubricant is required to facilitate assembly it shall have no detrimental effect on the gasket or on the pipe when subjected to prolonged exposure.
   7. Rotate the spigot by hand or with a strap wrench to verify proper jointing. If unusual joining resistance is encountered or if the insertion mark does not reach the flush position, disassemble the joint, inspect for damage, reclean the joint components and repeat the assembly steps.
   8. Use a bar and wood blocking to properly seat pipe joints. DO NOT USE BACKHOE BUCKET, OR SIMILAR MACHINERY, TO FORCE JOINT ASSEMBLY.

B. High Density Polyethylene Gravity Piping (HDPE):
   1. Install in accordance with the pipe manufacturer's specifications
   2. Completely clean all jointing surfaces and adjacent areas prior to making joints.
   3. Field cut pipe for shorter than standard pipe lengths. Cut ends square and perpendicular to the pipe axis. Remove and smoothly bevel ends.
   4. Assemble all joints in accordance with recommendations of the manufacturer. If a lubricant is required to facilitate assembly, it shall not have a detrimental effect on the gasket or on the pipe when subjected to prolonged exposure.

3.4 FIELD QUALITY CONTROL

A. General:
   1. Notify Engineer at least 48 hours in advance of all testing.
   2. Provide all testing apparatus including pumps, hoses, gauges, fittings, temporary bulkheads, plugs, compressors and miscellaneous other required items.
   3. Provide temporary blocking and bracing or approved thrust and joint restraint to prevent joint separation and pipe movement during testing.
   4. Unless otherwise approved, conduct all tests in the presence of the Engineer and in the presence of local authorities having jurisdiction.
   5. Water Source:

a. Provide all water for testing, flushing, and other water uses. The source of the water shall be subject to the approval of the Engineer.
b. The point of introduction of water for conducting tests shall be subject to the approval of the Engineer.

6. All costs for tests shall be included in the Contractor's bid.
7. Locate, and repair or replace, section of piping which fail the test and retest until acceptance.

B. Required Tests for Gravity Sanitary Sewers:

1. Perform the following tests after all the sewer pipe has been installed and prior to final acceptance.
   a. Deflection Test
   b. Alignment Test
   c. Low Pressure Air Test
   d. Corroborative Infiltration/Exfiltration Test
   e. Television Inspection, if required based on results of (c) and (d) above.
2. Perform tests prior to placement of pavement, or other construction which may, in the opinion of the Engineer, be detrimentally affected by excavation required for repairs.
3. Perform the tests only after the backfill has been in place to its full depth for a minimum of 30 days.
4. Submit details prior to making tests of proposed testing procedures with a description of methods and equipment to the Engineer for approval.
5. Deflection Test:
   a. Deflection test all flexible sewer pipe with a "go/no-go" mandrel with a diameter equal to 95% of the inside diameter of the pipe.
   b. Maximum pipe deflection: 5 percent.
6. Alignment Test:
   a. Alignment test all sewer pipe with the hand-lamp method.
   b. The full diameter of the pipe shall be visible when viewed between consecutive manholes.
7. Air Test:
   a. Air test all sewer pipe, including laterals, in conformance with ASTM F1417. The length of lateral piping shall not be considered in the calculation of acceptance times.
   b. Commensurately increase test pressure for groundwater elevations above the pipe, in accordance with UNI- B-6 by Uni-Bell Plastic Pipe Association.
   c. Method:
      1) Clean and wet thoroughly the inside of the pipe before test is performed.
      2) Insert test plugs in ends of pipe to be tested.
      3) Slowly fill the pipe with air to a pressure of 4 psig. Maintain pressure between 4 and 3.5 psig for at least 2 minutes for temperature stabilization.
      4) Check all plugs for tightness.
      5) With a pressure of approximately 4 psig in pipe, disconnect air supply.
      6) Allow pressure to decrease to 3.5 psig.
      7) Determine elapsed time for pressure drop from 3.5 psig to 2.5 psig.

d. The line is considered acceptable if the time for the pressure to decrease from 3.5 psig to 2.5 psig is not less than the amount determined by the following table, except that Reinforced Concrete Pipe shall be half this duration.

MINIMUM ACCEPTANCE TIMES			
PIPE DIAMETER (IN.)	**MINIMUM TIME (MIN:SEC)**	**LENGTH FOR MINIMUM TIME (FT.)**	**TIME FOR LONGER LENGTH (SEC.)**
4	3:46	597	0.380 L
6	5:40	398	0.854 L
8	7:34	298	1.520 L
10	9:26	239	2.374 L
12	11:20	194	3.418 L
15	14:10	159	5.342 L
18	17:00	133	7.692 L
21	19:50	114	10.470 L
24	22:40	99	13.674 L
27	25:30	88	17.306 L
30	28:20	80	21.366 L
33	21:10	72	25.852 L
36	34:00	66	30.768 L
Where L is the test length.			

e. If the leakage in the section tested exceeds the specified amount, repair or replace the section tested to reduce the leakage to within the specified limits and repeat the test until the leakage requirements are met.

f. The Contractor may, at his option, infiltration/exfiltration test all sewer pipe in lieu of the air test.

8. Corroborative Infiltration/Exfiltration Test:
   a. Where air testing is used for leakage testing, corroborative infiltration/exfiltration testing shall be performed.
   b. Test the 3 sewer sections which indicate the greatest rate of air loss.
   c. If the infiltration/exfiltration tests prove acceptable no additional testing is required; however, if the air test is not verified by the corroborative testing, complete infiltration/exfiltration testing shall be required as the basis for final acceptance.
9. Infiltration Test:
   a. Use the infiltration test when groundwater levels are at least 2 feet above the top of the pipe for the lengths of the section tested during the period of the tests.
   b. Measure leakage by a watertight well, weir, or other approved means installed at the lower end of each section under test.
   c. Test for a period of at least 3 days.
   d. Total leakage of any section tested shall not exceed the rate of 200 or 50 gallons per mile of pipe per 24 hours per inch of nominal internal diameter for concrete and PVC pipe, respectively.

e. If the leakage in the section tested exceeds the specified amount, repair or replace the sections to reduce the leakage to within the specified limits and repeat until the leakage requirements are met.

10. Exfiltration Test:
    a. Use the exfiltration test if the groundwater levels are less than 2 feet above the top of the pipe for the lengths of the section tested during the period of the test.
    b. Fill the pipe and manhole with water to provide a positive differential head of at least 2 feet on the top of the pipe (or the top of the groundwater) at the highest point of the pipeline under test.
    c. During exfiltration testing the maximum internal pipe pressure at the lowest end shall not exceed 25 feet of water.
    d. The amount of water added to maintain this head shall be the leakage.
    e. Test for a period of at least 4 hours.
    f. Total leakage of any section tested shall not exceed the rate of 200 gallons or 50 gallons per mile of pipe per 24 hours per inch of nominal internal diameter for concrete and PVC pipe, respectively.
    g. If the leakage in the section tested exceeds the specified amount, repair or replace sections to reduce the leakage to within the specified limits and repeat the test until the leakage requirements is met.
    h. On steep grades it may be necessary to place plugs in the pipe between manholes to avoid excessive pressures in the sewer pipe and against the caps at the end of house and building connections.
11. Television Inspection:
    a. If a section of sewer has failed the air and exfiltration/infiltration tests, or is proven poorly aligned by the lamp test, inspect the sewer by closed-circuit television to locate and repair defective section of sewer.
    b. The Engineer will notify the Contractor in writing which completed sewers shall be inspected by closed-circuit television and commence the television inspection within 15 days of the Engineer's written notification.
    c. Notify the Engineer at least 5 days prior to commencement of television inspection.
    d. No television inspection shall be performed without the Engineer or his representative present to witness the inspection.
    e. Provide the Engineer with 3 copies of a report of the televising inspection of each section of completed sewer inspected. Show the exact location and extent of all cracks, loose joints, holes, vertical and horizontal, misalignment, faulty service connections, caved-in pipe, points of infiltration, obstructions, debris and all else detrimental to the proper functioning and service of the completed sewer. Provide the actual television inspection video with the report showing all the above conditions found, at all wyes, tees, and laterals and as directed by the Engineer. The Engineer will review the report and will instruct the Contractor, to repair any conditions which, in the opinion of the Engineer, are detrimental to the proper function and service of the sewer.
12. Visual Inspection: Prior to final acceptance, a visual inspection of all appurtenance structures (i.e. manholes, chambers, etc.) will be required. Repair visual leaks, regardless of their magnitude.

C. Required Tests for Storm Sewers:

1. Perform the following tests after the storm drainage pipe has been installed and prior to final acceptance:
   a. Alignment Test for all pipe.
2. Based upon visual observations, the Engineer may order additional testing including the following:
   a. Television Inspection, if required by the Engineer.
   b. Deflection Test, if required by the Engineer
   c. Water-tight field test ASTM F1417 if required by the Engineer.
3. Perform tests prior to placement of pavement, or other construction which may, in the opinion of the Engineer, be detrimentally affected by excavation required for repairs.
4. Submit details prior to making tests of proposed testing procedures with a description of methods and equipment to the Engineer for approval.
5. Alignment Test:
   a. All storm drainage pipe will be subject to a visual inspection in order to identify proper alignment, grade, and excessive deflection.
   b. The Engineer may choose to perform an alignment test using the hand-lamp method, in which case the full diameter of the pipe shall be visible when viewed between consecutive structures.
6. Television Inspection:
   a. The Engineer will notify the Contractor in writing which completed sewers shall be inspected by closed-circuit television.
   b. The Contractor shall commence the television inspection within 15 days of the Engineer's written notification. The Contractor shall notify the Engineer at least 5 days prior to commencement of television inspection.
   c. No television inspection shall be performed without the Engineer or his representative present to witness the inspection.
   d. The Contractor shall provide the Engineer with 3 copies of a report of the televising inspection of each section of completed sewer inspected. Show the exact location and extent of all cracks, loose joints, holes, vertical and horizontal, misalignment, faulty service connections, caved-in pipe, points of infiltration, obstructions, debris and all else detrimental to the proper functioning and service of the completed sewer. The Contractor shall provide the actual television inspection video with the report showing all the above conditions found, at all wyes, tees and laterals and as directed by the Engineer.
   e. The Engineer will review the report and will instruct the Contractor, to repair any conditions which, in the opinion of the Engineer, are detrimental to the proper function and service of the storm pipe.
7. Deflection Test:
   a. The Engineer will notify the Contractor in writing which completed sewers shall be tested by the deflection method.
   b. The Contractor shall commence the deflection test within 15 days of the Engineer's written notification. The Contractor shall notify the Engineer at least 5 days prior to commencement of television inspection.
   c. No Deflection testing shall be performed without the Engineer or his representative present to witness the test.

d. The deflection test shall be performed on flexible drainage pipe with a "go/no-go" mandrel with a diameter equal to 95 percent of the inside diameter of the pipe being tested.

e. The maximum pipe deflection shall be 5 percent.

f. The Engineer will review the Deflection Test results and will instruct the Contractor, to repair any conditions which, in the opinion of the Engineer, are detrimental to the proper function and service of the storm pipe.

8. Visual Inspection: Prior to final acceptance, a visual inspection of all appurtenance structures (i.e., manholes, chambers, etc.) will be required. Repair visual leaks, regardless of their magnitude.

END OF SECTION 330500

SECTION 330513 – MANHOLES AND STRUCTURES

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the following:
   1. Installation of manholes, catchbasins, precast concrete structures, frames, grates, covers, steps, and piping connections as shown on the Drawings and as specified herein.
   2. Alteration of existing structures as shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:
   1. American Society of Testing and Materials (ASTM).
   2. American National Standards Institute (ANSI).
   3. Occupational Health and Safety Administration (OSHA).

1.3 SUBMITTALS

A. Shop Drawings: Submit the following for approval:
   1. Design and construction details of all precast concrete units.
   2. Fabrication, assembly, and installation details for all castings and miscellaneous metal works.
   3. Precast concrete structure design calculations verifying the structures have been designed to withstand the burial, submergence and anticipated live and dead loads. Design calculations for uplift forces shall incorporate a minimum factor of safety of 1.15.

B. Product Data:
   1. Manufacturer’s catalog cuts, specifications, and installation instructions.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site to prevent interruption of the Work.

B. All materials shall be inspected by the Contractor upon delivery to the site. The Contractor shall notify the Engineer of any loss or damages. Replace loss or repair damage to new condition at the Contractor’s expense.

C. Store materials to allow easy access for inspection and identification.

PART 2 – PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Design: In accordance with ASTM C890 – Minimal Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

B. Loading: AASHTO HS-20 with 30 percent impact and 130 pound/cubic foot equivalent soil pressure.

2.2 PRECAST CONCRETE DRAINAGE STRUCTURES

A. Drainage manholes shall conform to subpart "Precast Concrete Manholes."

B. Catch basins with greater than 6 feet sidewall depth shall conform to subpart "Precast Concrete Manholes."

C. Catch basins with less than or equal 6 feet sidewall depth shall be 2-foot 6-inch by 2-foot 6-inch square I.D.

D. Precast catch basin units shall conform to the dimensions shown on the Drawings and as detailed in Shop Drawings approved by the Engineer.

E. Unless otherwise specified precast concrete units shall conform to ASTM C478.

F. A precast concrete slab, as necessary for proper frame and grate placement, shall be provided at the top of the catch basin unit. The slab shall be designed for an H-20.

2.3 PRECAST CONCRETE MANHOLES

A. Precast manhole units shall conform to the dimensions shown on the Drawings and as detailed in Shop Drawings approved by the Engineer.

B. Unless otherwise specified, manhole sections shall conform to ASTM C478.

C. Precast structure bases shall be of the "base unit" type, with an integral base and barrel section. The barrels shall be constructed in increments of 1 foot to provide the indicated height with the fewest joints. Openings for pipe connections will not be permitted closer than 1 foot to the nearest joint. Mark the date of manufacture and name or trademark of manufacturer in the inside of each section.

D. Manholes barrels, servicing pipes less than 27-inch diameter, shall be 48-inch diameter. Manholes barrels, servicing pipes 27-inch diameter and larger shall be 60-inch diameter. Larger diameter manholes barrels shall be provided as indicated on the Drawings or as specified herein.

E. Joints shall be rubber and concrete using O-ring gaskets (ASTM C443) or butyl rubber gaskets (ASTM C443), or tongue and groove buttered with 1:2 cement mortar (ASTM C270, Type M). A precast eccentric cone, or precast slab where shown, shall be provided at the top of the manhole barrel to receive the frame and cover. The slab or cover shall be designed for an H-20 loading.

F. Precast manhole units shall be coated on the exterior with a two-coat application of polyamide-cured epoxy-coal tar. Application shall meet manufacturer's recommendations. Do not apply the polyamide-cured epoxy-coal tar within 28 days of concrete manufacture. Epoxy-coal tar to be as manufactured by Coopers Creek Chemical Corporation, Cooper Black #775 Epoxy Tar Coating or approved equal.

2.4 MANHOLE STEPS

A. Manhole sections shall contain manhole steps at 12 inches on center for all structures over 3 feet 6 inches in height. The steps shall be embedded in the concrete and accurately positioned both vertically and horizontally.

B. Steps shall be capable of withstanding a 300-pound concentrated live load without permanent distortion, conforming to the requirements of ANSI A14.3, OSHA, and the details shown on the Drawings.

C. Manhole rungs shall be steel reinforced copolymer polypropylene plastic. Rungs shall be 14 in. wide, M.A. Industries type PS2-PF, or equal. Copolymer polypropylene shall be type II, grade 16906 meeting ASTM D4101. Steel reinforcing shall be 3/8-inch diameter, Grade 60 conforming to ASTM A615 and shall be continuous throughout the rung. The portion of the legs to be embedded in the precast section shall have fins and be tapered to insure a secure bond.

D. Frames and covers shall be as shown on the Drawings. Otherwise, conform to the standard detail of the regulatory authorities having jurisdiction for the project (if applicable). Access clear width shall be a minimum of 24-inches.

2.5 FRAMES AND COVERS/GRATES

A. Frames and covers/grates shall be cast iron, ASTM A48, Class 30, free from flaws or unsightly defects.

B. Frames and covers shall conform to the details on the Drawings and have "SANITARY SEWER" or "STORM SEWER" cast on every cover.

C. Frames and covers/grate**s** shall be designed for an H-20 loading and be machined to ensure correct fit and even bearing.

D. Frames and covers/grates shall be as shown on the on the Drawings. Otherwise, conform to the standard detail of the regulatory authorities having jurisdiction for the project (if applicable).

2.6 GRADE ADJUSTMENTS

A. Grade Rings: Reinforced-concrete rings, 3- to 12-inch (75- to 300-mm) total thickness, to match diameter of manhole frame and cover.

2.7 GROUT

A. Description: ASTM C1107, 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 (34.5 MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.8 DROP INLET

A. Drop inlets for manholes shall be constructed where shown on the Drawings and shall conform with the details shown on the Drawings.

B. Pipe and fittings shall be the same type and class as the sewer pipe beings installed.

C. Concrete for pipe encasement shall be 3,000 psi.

PART 3 – EXECUTION

3.1 EARTHWORK

A. Earthwork shall be in accordance with Section “Trenching and Backfilling” or Section “Earth Moving.”

3.2 PRECAST MANHOLE SECTIONS

A. Base units shall be placed on a minimum 12-inch foundation of pipe zone bedding material, and be set at the proper elevation, carefully leveled, and aligned.

B. Barrel units shall be set vertical with steps and sections in proper alignment. All joints shall be sealed with cement mortar inside and out, and troweled smooth to the contour of the wall surface. Joints shall be installed in accordance with manufacturer’s recommendations.

C. Lifting holes shall be sealed tight with a tapered solid rubber plug driven into the hole and the remaining void filled with mortar on the outside only.

3.3 GRADE RINGS

A. Grade rings placed upon the eccentric cone or slab shall be used for all manholes to provide the potential for future adjustment.

B. Grade rings shall be placed in a combined thickness of at least 4 inches but not more than 12 inches in order to bring the manhole frame to proper grade.

C. Consecutive grade ring layers shall be laid on an even mortar bed.

3.4 PIPE CONNECTIONS

A. Pipe connections to manholes shall be installed true to line and grade as shown on the Drawings. Wall fittings shall be watertight, compatible with the sewer pipe joint. Connections shall conform to the details shown on the Drawings.

3.5 INVERT CHANNEL AND BENCH WALLS

A. An invert channel and bench walls shall be constructed as shown on the Drawings to provide a smooth transition in flow through the manhole. The invert channel and bench wall shall be constructed of 3,000 psi concrete. Benches shall be built-up to the height called for on the Drawings, or as directed by the Engineer, and given a steel trowel finish. Care shall be taken to slope all benches for proper drainage to the invert channel.

3.6 FRAMES

A. Frames shall be firmly set and bonded at the proper grade to conform with the finished grade shown on the Drawings.

B. Frames for manholes in unpaved areas shall be set at an elevation higher than finished grade as shown on the Drawings or as directed by the Engineer.

3.7 WATERTIGHTNESS

A. All manholes shall be free of visible leakage. Each manhole shall be inspected, and all leaks shall be repaired in a manner approved by the Engineer.

B. Testing: Manhole Negative Air Pressure (Vacuum) Test shall be performed prior to backfilling and in accordance with ASTM C1244.

1. Preparation of manhole
2. All lift holes shall be plugged.
3. All pipes entering the manhole shall be temporarily plugged, taking care to securely brace the pipe and plugs to prevent them from being drawn into the manhole during testing.
4. Procedure
5. The test apparatus shall be placed at the top of the manhole in accordance with the manufacturer’s recommendations.
6. A vacuum of 10 inches (254 mm) of mercury shall be drawn on the manhole. The valve on the vacuum line of the test apparatus shall be closed and the vacuum pump shut off.
7. The time shall be recorded for the vacuum to drop to 9 inches (229 mm).
8. If the time recorded exceeds the values in the following table, based on the manhole’s depth and diameter, the manhole is acceptable.

DIAMETER (IN.)			
DEPTH (FT)	48"	60"	72"
	TIME (SEC.)		
8	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97

3.8 CONNECTION TO EXISTING STRUCTURES

A. The Contractor shall make connections to existing manholes as shown on the Drawings or as specified herein.

B. For connections to precast or cast-in-place concrete manholes, the Contractor shall core drill a hole 1 inch larger than the O.D. of the sewer pipe into the existing manhole at the location and elevation shown on the Drawings.

C. For connections to masonry manholes, the Contractor shall open the sidewall of the existing manhole by removing masonry units no more than necessary to accommodate the sewer pipe.

D. Connection methods shall be in accordance with the details shown on the Drawings. Any open spaces around the new pipe entry shall be sealed with non-shrink grout to prevent leakage.

E. The existing bench and channel shall be removed and reconstructed to permit flow through the manhole as it now exists and also for the new sewer pipe. Bench and channel reconstruction shall conform with the details on the Drawings, or as directed by the Engineer.

F. The Contractor shall be responsible for diverting flow through the manhole in order to allow bench and channel construction.

3.9 CHANGING ELEVATIONS OF EXISTING STRUCTURES

A. Lower existing frames of manholes by the removal of appropriate masonry courses, to the elevations shown on the Drawings or as directed by the Engineer.

B. Raise the existing frames of manholes by the addition appropriate grade rings to the elevations shown on the Drawings or as directed by the Engineer.

C. Where the manhole frames cannot be lowered by removal of masonry courses, such as may be the case with precast concrete manholes, the upper barrel section shall be removed and/or replaced with a section of less depth, to permit the necessary adjustment of the frame.

D. Frames and covers damaged during the Work shall be replaced at the Contractor's expense.

END OF SECTION 330513

SECTION 334100.20 – HIGH DENSITY POLYETHYLENE STORM UTILITY DRAINAGE PIPING

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the installation of polyethylene piping systems as shown on the Drawings and as specified herein.

B. All piping, fittings, and appurtenances shall be new, clean, and in accordance with material specifications. In no instance shall second- hand or damaged materials be acceptable.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable:
      a. Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering.
      b. Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).
      c. American Society of Testing and Materials (ASTM).

1.3 SUBMITTALS

A. Product Data:
   1. Submit manufacturer’s catalog cuts, specifications, and installation instructions for both pipe and coupling system.
   2. Submit manufacturer’s certification that product was manufactured, tested, and supplied in accordance with the standards specified herein.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage:
   1. Pipe, fittings, specials, appurtenances, and accessories shall be delivered to and stored within the Contractor’s work limits as shown on the Drawings.
   2. Special care shall be exercised during delivery and storage to avoid damage to the products.
   3. Products shall be stored so as to avoid unnecessary handling and in locations where they will not interfere with the Owner’s operations or public travel.

B. Handling:
   1. Pipe, fittings, special appurtenances, and accessories shall be handled carefully with approved handling devices in strict conformance with the manufacturer's recommendations.
   2. Products shall not be dropped nor shall products be otherwise dragged, rolled, or skidded.

C. Products cracked, gouged, chipped, dented, or otherwise damaged will not be approved and shall be removed and replaced at the Contractor's expense, unless the product can be repaired in a manner acceptable to the manufacturer and Engineer. All repairs shall be at the Contractor's expense.

PART 2 – PRODUCTS

2.1 MATERIALS

A. HDPE Soil Tight Pipe:
   1. Pipe shall be ADS N-12 ST IB (per AASHTO) smooth interior with annular exterior corrugations and a Manning's "n" value of 0.012 high-density polyethylene pipe (HDPE) as manufactured by Advanced Drainage Systems (ADS) or approved equal. Pipe shall have an integral soil tight gasketed bell and spigot.
      a. 4 inches through 11 inches conforming to AASHTO M252 Type S.
      b. 12 inches through 60 inches conforming to AASHTO M294 Type S or ASTM F2306.
   2. Pipe shall be joined using a bell and spigot joint meeting AASHTO M252 M294 ASTM F2306. The joint shall be soil-tight and gasketed and shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.
   3. Fittings shall conform to ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the soil-tight joint performance requirements of ASTM F2306.

B. HDPE Water Tight Pipe:
   1. Pipe shall be ADS N-12 WT IB (per AASHTO) smooth interior with annular exterior corrugations and a Manning's "n" value of 0.012 high-density polyethylene pipe (HDPE) as manufactured by Advanced Drainage Systems (ADS) or approved equal. Pipe shall have an integral water tight gasketed bell and spigot or approved equal.
      a. 4 inches through 11 inches conforming to AASHTO M252 Type S.
      b. 12 inches through 60 inches conforming to AASHTO M294 Type S or ASTM F2306.
   2. 4 inches through 60 inches (100 to 1500 mm) shall be watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and

covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly 12- through 60-inch (300 to 1500 mm) diameters shall have a reinforced bell with a bell tolerance device. The bell tolerance device shall be installed by the manufacturer.

3. Fittings shall conform to ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the water-tight joint performance requirements of ASTM F2306.

C. Flared End Section:

1. Flared end sections shall be 1210 NP or 1810 NP HDPE end sections as manufactured by ADS or equal.
2. End sections shall be fastened to the last corrugation of the pipe length using a high strength nylon cable tie supplied by the manufacturer through pre-drilled holes at the top of the end section collar.

PART 3 – EXECUTION

3.1 INSPECTION

A. Inspect all pipe and fittings prior to laying in the trench. Remove defective pipe and fittings from the site.

B. Do not backfill until inspection by the Engineer, unless otherwise approved by the Engineer.

3.2 INSTALLATION AND TESTING

A. Trenching, backfilling and compaction shall conform to Section “Trenching and Backfilling.”

B. Pipe installation and testing shall conform to Section “Common Work Results for Utilities.”

END OF SECTION 334100.20

SECTION 334616.19 – UNDERDRAINS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes the installation of underdrains, cleanouts, and other appurtenances as shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. The latest edition of the following standards, as referenced herein, shall be applicable:
      a. Standard Specifications, Construction and Materials, New York State Department of Transportation, Office of Engineering.
      b. American Society of Testing and Materials (ASTM).

B. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of soils and aggregate with the specifications, in accordance with Section “Quality Requirements.”

1.3 SUBMITTALS

A. Samples:
   1. The Contractor shall furnish earth materials to the testing laboratory for analysis and report as directed by the Engineer or as outlined in the specifications.

B. Product Data:
   1. Submit manufacturer’s catalog cuts, specifications and installation instructions for the following:
      a. Pipe.
      b. Filter Fabric.
      c. Inspection Frame and Cover.

C. Test Results:
   1. The testing laboratory shall submit written reports of all tests, investigations, and recommendations to the Contractor and the Engineer.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Underdrain Pipe:

1. Shall conform to Section “High Density Polyethylene Storm Utility Drainage Piping.”
2. 6-inch HDPE, perforated.
3. Perforations: 1/8 to 3/16 inches.

B. Underdrain Filter - shall consist of crushed stone, sand, gravel, or screened gravel free from organic or other deleterious material meeting the following gradation requirements (NYSDOT Section 605, Type II):

SIEVE	PERCENT PASSING
1/2"	100
1/4"	20 - 100
No. 10	0 – 15
No. 20	0 – 5

C. Filter Fabric:
1. In accordance with Section "Geotextiles."

D. Cleanouts:
1. Fittings and solid wall pipe shall conform to Section “High Density Polyethylene Storm Utility Drainage Piping.”
2. Inspection Frame and Cover: Neenah R-1976 with Type “H” locking device or equal.
3. Concrete: 4000 psi, 4 to 8 percent air entrainment, 2- to 4-inch slump.

PART 3 – EXECUTION

3.1 PREPARATION

A. Trench excavation shall conform to Section “Trenching and Backfilling.”

B. Hand trim excavations to required elevations. Correct over excavation with fill material of select granular fill.

C. Remove large stones or other hard matter which could damage material installation or impede consistent backfilling or compaction.

3.2 INSTALLATION

A. Following preparation of the subgrade place filter fabric as indicated on the Drawings.
1. The fabric shall be placed across the trench at approximately right angles to its centerline.
2. The fabric strips shall overlap by a minimum of 12 inches.
3. Fabric shall be protected at all times during construction from contamination by eroded material. If contamination occurs, the fabric shall be removed and replaced with uncontaminated fabric.

4. Any fabric damaged during the installation shall be replaced by the Contractor at no additional cost.
5. After installation of the filter fabric the specified filter material shall be placed immediately.

B. Place, level, and compact a 6-inch bed of underdrain filter material just prior to placement of underdrain piping.

C. Place pipe with perforations down and install the pipe in accordance with Section "Common Work Results for Utilities" and manufacturer's installation instructions. Lay pipe to the slope and invert elevations shown on the Drawings.

D. After the pipe installation has been inspected by Engineer, underdrain filter shall be loosely placed around and over the pipe to such a depth that, after compaction, underdrain filter will extend to a level 6 inches above the underdrain pipe. Subsequent lifts of underdrain filter shall be no more than 6 inches thick prior to compaction and shall be compacted by 2 passes of a vibrating pad or drum type compactor.

E. Place filter fabric over leveled top surface of underdrain filter and lap 12 inches minimum prior to subsequent backfilling operations.

F. Install underdrain cleanouts of terminal points as shown and detailed on the Drawings. Ensure backfill is thoroughly compacted prior to placement of the concrete pad to support the inspection frame and cover. Place treated building paper around the periphery of the pipe, where it penetrates the concrete pad, to allow vertical movement of the pad.

G. Provide Owner with any "special" wrench or hardware required to operate the inspection cover locking device.

END OF SECTION 334616.19