# PROJECT MANUAL

**VOLUME II**

**BID SET**

**SEPTEMBER 2024**

# EADDY BUILDING- ADDITION AND RENOVATION
# SCO# 22-24471-02A

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# VOLUME I

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# SECTION 22 01 00 – PLUMBING GENERAL WORK REQUIREMENTS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. This section includes general requirements and information for Division 22 work.

### 1.2. DEFINITIONS

A. Owner Acceptance / Substantial Completion: Work that is judged by the Engineer to be substantially complete, accepted to be safe for use by the Authority Having Jurisdiction (AHJ), and accepted by the Owner. Acceptance comes with an agreement the Engineer's written punchlist of outstanding items will be completed to fulfill the contractual obligations.

B. Full Owner Occupancy: Owner will occupy the site and existing building during entire construction period.

C. Partial Owner Occupancy: Owner may occupy completed areas of building before Owner Acceptance.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

E. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

F. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

G. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

H. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

I. Provide: Contractor shall furnish and install materials, equipment, or fixtures as indicated.

J. Install Items Furnished by Owner or Others: Contractor shall receive shipment, store, install and verify materials, equipment, or fixtures selected and purchased outside of the prime construction contract as indicated.

K. Furnish Items to Owner or Others: Contractor shall purchase and deliver materials, equipment, or fixtures for installation by others as indicated.

### 1.3. SUBMITTALS

A. Construction Submittals: Manufacturer startup, operation, and maintenance checklists for all equipment and devices included in Division 22 specifications in a single submittal package for review prior to equipment startup.

B. Closeout Submittals: Manufacturer startup, operation, and maintenance reports with completed checklists signed by the involved technicians and the Plumbing Contractor's witnessing superintendent.

1.4. INSPECTIONS

A. Contractor shall be responsible for obtaining all inspections from regulatory agencies having jurisdiction over the project. These inspections include but are not limited to: NC Department of Labor Boiler Safety Bureau for boilers and pressure vessels, NC Department of Insurance, and other Local, State, and Federal inspection authorities as applicable.

1.5. WARRANTY

A. Project Warranty: All work performed and all materials installed in Division 22 shall be warrantied by the Contractor for 1 year from the Owner's written acceptance. The warranty shall include all labor and parts. The Contractor shall be on site within 48 hours of Owner notifications.

1. This warranty does not waive the Owner's obligation to provide routine maintenance. Routine maintenance includes maintenance recommended by each equipment manufacturer and industry standard requirements for overall systems as documented in the project's Operation and Maintenance Manuals. Replacement of wear items such as filters, etc. are not included in the warranty unless they are incidental to other warranty work being performed. Failures due to the lack of routine maintenance are the responsibility of the Owner.

2. Equipment manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the obligations of the Project Warranty.

3. Extended or special warranties defined in other sections shall be in addition to, and run concurrently with, the Project Warranty.

1.6. PROJECT DOCUMENTS

A. Project Documents: Division 22 project documents are diagrammatic in nature and intended to represent complete and functioning systems. If any aspect of the work is undefined or unclear, the contractor shall submit questions in writing prior to the final addendum deadline as defined in the specifications and/or at the pre-bid conference. If any aspect of the work is undefined or unclear after the final addendum, include the cost for the highest quality solution. The contractor is encouraged to thoroughly review the contract documents and site conditions prior to bidding.

B. Basis of Design Manufacturers: Manufacturer names and model numbers of equipment and devices noted on drawings and in equipment schedules shall be considered the Engineer's basis of design. Proposed changes to the basis of design shall be submitted to the Engineer for review and approval. The submittal shall include a description of all changes necessary to implement the substitution, including but not limited to plumbing, mechanical and electrical connections; dimensions, weights and structural supporting structure; layout changes necessary to maintain clearances; and acoustical treatments. All changes required to implement a substitution is the responsibility of Contractor at no added cost to the Owner.

C. Listed Manufacturers: Manufacturers listed in the Division 22 specification sections and on drawings must meet all the requirements of the project documents. Listed manufacturers that do not meet the requirements will not be accepted. The manufacturer listing does not result in an automatic approval. In addition to construction and performance requirements, the proposed equipment must meet the indicated physical dimension, weight, acoustic, power, and control limitations of the project. Verify existing conditions in the field, when applicable, and proposed conditions prior to submitting equipment for Engineer review. When full project coordination drawings are not required, generate coordination drawings to the level of detail necessary to determine if the proposed equipment will comply with the project documents and manufacturer recommended maintenance clearances.

1. If a manufacturer's equipment does not meet the physical dimension, weight, acoustic, power, controls, and plumbing limitations of the project, a change order proposal may be submitted for the Owner's and Engineer's consideration. The proposal shall include all changes, including other trades, required and a reduction in cost to accept the non-conforming equipment. The base bid shall include equipment that fully meets the design requirements at no additional cost.

## 1.7. COORDINATION

A. Maintenance Access: Install equipment and devices in such a manner to be readily accessible for testing, adjusting, balancing, inspection, and maintenance. All concealed equipment and devices, including but not limited to equipment, valves, actuators, sensors, gauges, test ports, filter housings, etc., shall be installed above accessible ceilings, within accessible rooms or chases or within normally inaccessible construction with access doors. All access doors are not shown in the project drawings. All access doors shall be coordinated with the Engineer prior to the installation of the equipment or device. Equipment and/or devices not coordinated prior to installation, as judged by the Engineer, shall be removed and reinstalled at no added cost.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for plumbing installations.

C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.

## 1.8. VOC CONTENTS

A. Low Volatile Organic Compounds (VOC) Requirements: All adhesives, mastics, sealants and compounds factory or field applied that are installed indoors and all paint field applied shall be certified as low VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

PART 2 - PRODUCTS

2.1. CONCRETE MATERIALS

A. Concrete: Use the following unless otherwise indicated:

1. Miscellaneous Uses: Medium-weight aggregate with 4000 psi, 28-day minimum compressive strength.

B. Reinforcing Bars: ASTM A 615, Grade 60, deformed.

C. Welded Wire Steel Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

2.2. PATCHING MATERIALS

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

B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

2.3. ESCUTCHEONS AND FLOOR PLATES

A. Escutcheons:

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

B. Floor Plates:

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

PART 3 - EXECUTION

3.1. DOCUMENTATION OF PROJECT CONDITIONS

A. Project Conditions: Document in digital-format photos and video the existing project conditions and continue to document the conditions as the project progresses. Owner claims of contractor damage will be judged by the documented conditions.

3.2. OPERATION AND MAINTENANCE MANUALS

A. The contractors shall deliver one complete set of bookmarked manuals in electronic PDF format of all operation and maintenance manuals to the Owner through the Designer, two (2) weeks before the pre-final inspection is held. The manuals shall be bookmarked to a minimum of one level – ie: each major piece of equipment (chiller, boiler switchboard, water closet, water heater, etc.) or document category (warranties, parts list, contact information, etc.) The manuals shall be delivered by one of the following:

1. USB Drive.
2. CD/DVD.
3. Downloadable file from FTP Site.

B. Manuals shall include the following (at a minimum):

1. Index and page numbers.
2. Certificate of Owner Acceptance / Substantial Completion.
3. Summary sheet of warranties with dates noted and a copy of all warranties.
4. List of all subcontractors and suppliers with names, addresses, and phone numbers.
5. Special Inspection Reports.
6. Complete start-up, operation, and shutdown procedures for each system including sequence of events, locations of switches, emergency procedures, and any other critical items.
7. Complete set of all submittal data and current shop drawings (including 3rd party generated shop drawings) and equipment description showing all capacities and other operation conditions.

3.3. CONCRETE

A. Design, construct, erect, brace, and maintain formwork according to ACI 301.

B. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

C. Comply with ACI 301 for measuring, batching, mixing, transporting, and placing concrete.

3.4. WALL, FLOOR, AND ROOF OPENINGS

A. Exterior and interior wall, floor and roof openings made for duct, piping and conduit penetrations shall maintain the building's structural integrity. Install penetration sleeves, framing and lintels in accordance with the structural engineer.

3.5. ESCUTCHEONS AND FLOOR PLATES INSTALLATION

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

B. Install escutcheons with inside diameter to closely fit around pipe, tube, and insulation of piping and with outside diameter that completely covers opening.

1. New Piping: Install one-piece cast-brass type for new piping installations. Install deep-pattern type where piping sleeve protrudes from the floor or wall.
2. Existing Piping: Install split-casting brass type for existing piping installations.

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

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

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

E. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

# SECTION 22 05 17 – PLUMBING SLEEVES

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes sleeves and associated materials.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

## PART 2 - PRODUCTS

### 2.1. SLEEVES

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

B. Galvanized-Steel Wall Pipes: ASTM A 53, Schedule 40, with plain ends and welded steel collar; zinc coated.

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

D. Galvanized-Steel-Sheet Sleeves: Minimum 20-gauge thickness; round tube closed with welded longitudinal joint.

E. PVC pipe sleeves are not acceptable.

### 2.2. GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

## PART 3 - EXECUTION

3.1. SLEEVE INSTALLATION

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

1. Insulated piping systems shall have insulation continue through penetrations without interruption. Insulation joints shall not occur within sleeves.

B. Install sleeves in concrete floors, concrete roof slabs, and masonry walls as new slabs and walls are constructed.

1. Walls: Cut sleeves to length for mounting flush with both surfaces.

2. Floors: Extend sleeves 1-inch above finished floor and seal penetrations watertight.

3. Mechanical Equipment Room and Wet Area Floors: Extend sleeves 2-inches above finished floor and seal penetrations watertight.

4. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

C. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements of sealants.

3.2. SLEEVE SCHEDULE

A. Use sleeves for the following piping-penetration applications:

1. Galvanized Steel Pipe Sleeves: Interior fire-rated partitions; interior non-rated partitions; and concrete slabs above grade.

2. Galvanized Steel Sheet Sleeves: Interior non-rated partitions.

END OF SECTION

# SECTION 22 05 23 – PLUMBING PIPING VALVES

## GENERAL

### 1.1. SUMMARY

A. Section includes general duty valves for plumbing piping systems such as ball, check, and globe valves and associated accessories.

### 1.2. SUBMITTALS

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

### 1.3. QUALITY ASSURANCE

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

B. ASME Compliance:

1. ASME B31.9 for building services piping valves.

### 1.4. DELIVERY, STORAGE AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. 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.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

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

1. Apollo Valves / Conbraco.

2. Milwaukee Valve / Hammond Valve.

3. NIBCO.

4. Watts.

2.2. GENERAL REQUIREMENTS

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

B. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable water service.

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

D. Valve Pressure and 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 Types:

1. Hand Lever: For quarter-turn valves 4-inches NPS and smaller except plug valves.

G. Valves in Insulated Piping: Provide 2-inch stem extensions.

1. 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.

H. Valve-End Connections:

1. Threaded: With threads according to ASME B1.20.1.

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

2.3. BALL VALVES

A. Ball Valves, 2-inches NPS and smaller: Two-piece, full-port, quarter-turn, forged brass or bronze ball valves with stainless steel trim, PTFE seats, adjustable stem packing and anti-blowout stem, rated for 600 psig CWP (cold working pressure). Valves shall comply with MSS SP-110. Valves shall have threaded ends.

PART 3 - EXECUTION

3.1. EXAMINATION

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

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

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

D. Do not attempt to repair defective valves; replace with new valves.

3.2. VALVE INSTALLATION

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

B. Install valves in branch lines to isolate sections of the piping system.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe. Valves with stems below center of piping are not acceptable.

E. Install valves in position to allow full stem movement.

F. Valves shall be equipped with stem extensions for all applications where the piping will be insulated.

3.3. ADJUSTING

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

3.4. GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Piping systems shall use the following valve types unless otherwise indicated on the drawings or in other Division 22 sections:

1. Shutoff: Ball.

B. 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.

END OF SECTION

# SECTION 22 05 29 – PLUMBING HANGERS AND SUPPORTS

## GENERAL

### 1.1. SUMMARY

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

### 1.2. 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.

### 1.3. SUBMITTALS

A. Qualification Submittals: Welding certificates.

B. Product Submittals: For each type of product indicated.

### 1.4. QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

## PART 2 - PRODUCTS

### 2.1. METAL PIPE HANGERS AND SUPPORTS

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

B. Copper Pipe Hangers: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components. Hanger rods shall be continuously threaded with nuts and washers made of stainless steel.

## 2.2. TRAPEZE PIPE HANGERS

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

## 2.3. THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength. For cold piping systems, include vapor barrier.

B. Insert and shield shall cover the entire pipe circumference for trapeze of clamped systems and cover the lower 180-degrees of pipe circumference for clevis or band hangers.

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

## 2.4. EQUIPMENT SUPPORTS

A. Description: Premanufactured, metallic assemblies from a single manufacturer.

## 2.5. MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

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

# PART 3 - EXECUTION

## 3.1. HANGER AND SUPPORT INSTALLATION

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

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

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

D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

F. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at changes in direction of piping.

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. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping. Clamps may project through the insulation of hot piping systems. Use thermal hanger shield inserts with clamp sized to match outside diameter of insert for cold piping systems.

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

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

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

   a. Less than 4-inches NPS: 12-inches long and 0.060-inch thick.

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

## 3.2. EQUIPMENT SUPPORTS

A. Install in accordance with manufacturer's printed instructions and details on plans.

## 3.3. METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4. ADJUSTING

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

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

3.5. PAINTING

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

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

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6. HANGER AND SUPPORT SCHEDULE

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

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

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

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

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

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

G. Use padded hangers for piping that is subject to scratching.

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

I. Horizontal-Piping Hangers and Supports:

1. Adjustable Steel Clevis Hangers (MSS Type 1).

2. Split-Ring Hangers (MSS Type 69): Piping 2-inches NPS and smaller.

3. Copper Pipe Hangers: For copper piping.

J. Trapeze Pipe-Hangers: Trapeze hangers shall be welded carbon steel pre-formed structural members suspended by threaded rods. Comply with MSS SP-69. Each pipe shall be individually supported.

1. Adjustable Pipe Saddles (MSS Type 38).

2. Copper Pipe Saddles: For copper piping.

K. Vertical-Piping Clamps:

1. Riser Clamps (MSS Type 8).

L. Building Attachments: Install MSS compliant devices for all building attachments. Install them per manufacturer's instructions.

M. Saddles and Shields:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

3.7. PIPE HANGER INSTALLATION

A. Steel Piping: Install hangers for steel piping with the following minimum rod sizes and maximum spacing:

| **HORIZONTAL PIPE HANGER SCHEDULE (STEEL/CAST-IRON)** | | | | | | |
|---|---|---|---|---|---|---|
| SYSTEM | WATER | | FUEL GAS | | WASTE AND VENT | |
| MATERIAL | SCHEDULE 40 STEEL | | SCHEDULE 40 STEEL | | CAST-IRON SOIL DWV | |
| PIPE DIAMETER (INCHES) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) |
| 1/2 | 3/8 | 6 | 3/8 | 6 | | |
| 3/4 | 3/8 | 6 | 3/8 | 8 | | |
| 1 | 3/8 | 6 | 3/8 | 8 | | |
| 1 1/4 | 3/8 | 6 | 3/8 | 8 | | |
| 1 1/2 | 3/8 | 8 | 3/8 | 8 | 3/8 | 5 |
| 2 | 3/8 | 10 | 3/8 | 8 | 3/8 | 5 |
| 2 1/2 | 3/8 | 10 | 1/2 | 10 | | |
| 3 | 1/2 | 12 | 1/2 | 10 | 1/2 | 5 |
| 4 | 5/8 | 12 | 5/8 | 10 | 5/8 | 5 |
| 5 | 5/8 | 12 | 5/8 | 10 | 5/8 | 5 |
| 6 | 3/4 | 12 | 5/8 | 10 | 3/4 | 5 |
| 8 | 3/4 | 12 | | | 3/4 | 5 |
| 10 | 7/8 | 12 | | | 7/8 | 5 |
| 12 | 7/8 | 12 | | | 7/8 | 5 |
| 14 | 1 | 12 | | | | |
| 16 | 1 | 12 | | | | |
| 18 | 1 1/4 | 12 | | | | |
| 20 | 1 1/4 | 12 | | | | |
| 24 | 1 1/2 | 12 | | | | |

B. Copper Piping: Install hangers for drawn-temper copper piping with the following minimum rod sizes and maximum spacing:

| **HORIZONTAL PIPE HANGER SCHEDULE (COPPER)** | | | | | | |
|---|---|---|---|---|---|---|
| SYSTEM | WATER | | FUEL GAS | | MGAS / VACUUM | |
| MATERIAL | DRAWN-TUBE COPPER | | DRAWN-TUBE COPPER | | DRAWN-TUBE COPPER | |
| PIPE DIAMETER (INCHES) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) | MINIMUM HANGER ROD DIA. (INCHES) | MAXIMUM HANGER SPACING (FEET) |
| 1/2 | 3/8 | 5 | 3/8 | 4 | 3/8 | 6 |
| 3/4 | 3/8 | 5 | 3/8 | 6 | 3/8 | 6 |
| 1 | 3/8 | 5 | 3/8 | 6 | 3/8 | 8 |
| 1 1/4 | 3/8 | 5 | 3/8 | 8 | 3/8 | 8 |
| 1 1/2 | 3/8 | 8 | 3/8 | 8 | 3/8 | 10 |
| 2 | 3/8 | 8 | 3/8 | 8 | 3/8 | 10 |
| 2 1/2 | 1/2 | 8 | | | 1/2 | 10 |
| 3 | 1/2 | 10 | | | 1/2 | 10 |
| 4 | 5/8 | 10 | | | 1/2 | 10 |
| 5 | | | | | 1/2 | 10 |
| 6 | | | | | 5/8 | 10 |
| 8 | | | | | 3/4 | 10 |

C. Support vertical runs at roof, at each floor, and at 8-foot intervals between floors.

END OF SECTION

# SECTION 22 05 53 – PLUMBING SYSTEMS IDENTIFICATION

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes pipe labels and tags.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each type of product indicated.

B. Closeout Submittals:

1. Valve Schedules: For each piping system to include in maintenance manuals.

### 1.3. COORDINATION

A. Coordinate the identification requirements with the Owner's up-to-date standards prior to purchasing materials.

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 locations of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

### 2.1. PIPE LABELS

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

### 2.2. VALVE TAGS

A. Valve Tags: 0.032-inch thick brass or 0.025-inch thick stainless steel, stamped or engraved, with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers with pre-drilled or stamped holes for beaded chain or S-hook attachment hardware.

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.

## 2.3. CEILING TAGS

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

# PART 3 - EXECUTION

## 3.1. PREPARATION

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

## 3.2. PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

## 3.3. VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; 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.

3.4. CEILING TAG INSTALLATION

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

3.5. SYSTEM IDENTIFICATION SCHEDULE

A. Install equipment and piping identification materials with the color and abbreviations that match the Owner's standard practice. Refer to System Identification Schedule below.

| SYSTEM IDENTIFICATION SCHEDULE | | | |
|---|---|---|---|
| PIPING SYSTEMS | ABBREV. | BACKGROUND | LETTERING |
| DOMESTIC WATER | DCW/DHW/DHWR | GREEN | WHITE |
| NON-POTABLE WATER | NPW | LIGHT GRAY | WHITE |
| REAGENT WATER | DI/RO/DISTILLED | BROWN | WHITE |
| CONDENSATE DRAIN | CD | WHITE | BLACK |
| STORM DRAINAGE | STORM | BLACK | WHITE |
| SANITARY WASTE AND VENT | WASTE/VENT | BLACK | WHITE |
| ACID WASTE AND VENT | ACID WASTE/VENT | SAFETY YELLOW | BLACK |
| COMPRESSED AIR | AIR | LIGHT ORANGE | BLACK |
| INSTRUMENT AIR | CONFORM TO NFPA 99, TABLE 5.1.11 | | |
| MEDICAL-GRADE COMPRESSED AIR | CONFORM TO NFPA 99, TABLE 5.1.11 | | |
| VACUUM | CONFORM TO NFPA 99, TABLE 5.1.11 | | |
| MEDICAL GASES | CONFORM TO NFPA 99, TABLE 5.1.11 | | |
| FIRE PROTECTION | FIRE | BRIGHT RED | WHITE |
| NATURAL GAS | NG | YELLOW | BLACK |
| PROPANE GAS | LPG | YELLOW | BLACK |
| FUEL OIL | FO | YELLOW | BLACK |
| DIESEL FUEL | DIESEL | YELLOW | BLACK |
| OTHERS | SEE PLANS | WHITE | BLACK |
| VALVE TAGS | | BRASS | BLACK |
| EQUIPMENT AND DUCT SYSTEMS | ABBREV. | BACKGROUND | LETTERING |
| WARNING SIGNS | SEE PLANS | SAFETY YELLOW | BLACK |
| CEILING GRID MARKERS | SEE PLANS | CLEAR | BLACK |
| EQUIPMENT TAGS | SEE PLANS | BLACK | WHITE |

NOTE: PROVIDE FLOW ARROWS ON ALL PIPE MARKERS.

END OF SECTION

# SECTION 22 07 19 – PLUMBING PIPING INSULATION

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes insulation of plumbing piping systems.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

### 1.3. QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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. Indoors installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Indoors not installed in air plenums: Flame-spread index of 25 or less, and smoke-developed index of 450 or less.

### 1.4. DELIVERY, STORAGE AND HANDLING

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

B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material installed or not, that becomes wet, dirty, etc. shall be removed and replaced. “Dried” or “cleaned” insulation materials shall not be used.

### 1.5. COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with 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.

1.6. SCHEDULING

A. Schedule insulation installation after pressure testing. Insulation applied prior to satisfactory test results shall be removed and replaced.

PART 2 - PRODUCTS

2.1. INSULATION MATERIALS

A. General: Comply with requirements in Piping Insulation Schedule and Field-Applied Jacket Schedule articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, formaldehyde, lead, mercury, or mercury compounds.

2. Fitting Covers: Field apply insulation to cover valves, elbows and tees.

B. Mineral-Fiber, Preformed Pipe Insulation:

1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL.

2. Thermal conductivity (k-value) maximum value of 0.34 BTU in /(hr sqft deg F) for fluid temperatures above 350 °F; 0.32 for fluids 350 °F and lower; 0.30 for fluids 250 °F and lower; 0.29 for fluids 200 °F and lower; 0.27 for fluids 60 °F and lower; and 0.26 for fluids 40 °F and lower.

2.2. FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets for various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White outward facing, bleached kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.3. FIELD-APPLIED JACKETS

A. Insulation system schedules indicate field-applied jackets for various applications. When field-applied jackets are indicated, comply with the following:

1. PVC Jacket: High-impact resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C, 20-mils thick.

   a. Adhesive: As recommended by jacket material manufacturer.

   b. Color: Comply with Section 22 05 53.

c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

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

## 2.4. INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

# PART 3 - PRODUCTS

## 3.1. PIPING INSULATION INSTALLATION MATERIALS

A. General: Adhesives, mastics and sealants shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Indoor applications shall comply with low-VOC requirements of Section 220100.

B. Adhesives:

1. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

3. PVC Jacket Adhesive: Compatible with PVC jacket.

C. Mastics: Comply with MIL-PRF-19565C, Type II.

1. Vapor-Barrier Mastic: Water based, white, suitable for indoor use on below-ambient services with water-vapor permeance of 0.013 perm at 43-mil dry film thickness per ASTM E 96, Procedure B; service temperature range of minus 20 to plus 180 deg F; and solids content of 58 percent by volume and 70 percent by weight per ASTM D 1644.

2. Breather Mastic: Water based; white, suitable for indoor and outdoor use on above-ambient services with service temperature range of minus 20 to plus 180 deg F; water-vapor permeance of 1.8 perms at 0.0625-inch dry film thickness per ASTM F 1249; and solids content of 60 percent by volume and 66 percent by weight.

D. Sealants:

1. Joint Sealants: Permanently flexible, white or gray, elastomeric sealant with service temperature range of minus 100 to plus 300 °F.

2. ASJ Flashing Sealants and Vinyl and PVC Jacket Flashing Sealants: Fire and water-resistant, white, flexible, elastomeric sealant with service temperature range of minus 40 to plus 250 °F.

E. Tapes:

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

F. Securements:

1. Bands:

a. Stainless Steel: ASTM A 167 or ASTM A 240, Type 304 or Type 316; 0.015-inch thick, 3/4-inch wide with wing seal.

b. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch thick, 3/4-inch wide with wing seal.

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

3. Wire: 0.062-inch soft-annealed, stainless steel.

3.2. INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. Mineral-Fiber: 1/2-inch thick for 1/2 to 1-1/4-inches NPS and 1-inches thick for 1-1/2-inches and larger.

3.3. FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Indoor Equipment and Piping Jacket:

1. Concealed Piping: None.

2. Exposed Piping:

a. Up to 12 feet above floor: 20 mils thick PVC.

b. Greater than 12 feet above floor: Woven canvas.

3.4. 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.

3.5. PREPARATION

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

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

3.6. 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. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches on center.

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 2 inches on center.

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.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

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

P. Piping insulation shall be continuous and not interrupted by hangers and supports. Hangers shall include factory-fabricated galvanized steel insulation shields that comply with MSS-58. Insulation installed that encapsulates any part of the hanger shall be removed and reinstalled.

3.7. PENETRATIONS

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

3.8. 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, and Unions:

1. Install insulation over fittings, valves, strainers, 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 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, install fitted PVC cover over elbows, tees, strainers, valves, 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 necessary to access components. Installation shall conform to the following:

1. Make removable union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When union covers are made from sectional pipe insulation, extend insulation from union long at least two times the insulation thickness over adjacent pipe insulation on each side of union. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for unions, except divide the two-part section on the vertical center line of valve body.

3.9. 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. 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 surfaces, secure laps with outward-clinched staples at 6 inches on center.

4. 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.

## 3.10. FIELD-APPLIED JACKET INSTALLATION

A. 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.

## 3.11. FINISHES

A. Paint pipe insulation with ASJ, glass-cloth, or other paintable jacket material. Color shall be selected by the Owner/Engineer. Refer to Section 22 05 53 – Plumbing Systems Identification.

1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.

2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.

B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55 °F; not more than 90 °F; and not more than 70% relative humidity.

END OF SECTION

# SECTION 22 11 16 – DOMESTIC WATER PIPING

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for domestic water piping.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Pipe and fitting manufacturing source list confirming the materials will be products of the United States of America.

B. Construction Submittals: System purging and disinfecting reports.

C. Closeout Submittals: Final disinfecting report.

### 1.3. QUALITY ASSURANCE

A. All piping and fittings shall be products of the United States of America. All other piping and fittings will be removed from the project at the contractor’s expense.

1. This requirement does not apply to piping that is internal to and factory-fabricated and installed in unitary equipment. The requirement does apply to all field-installed piping and skid-mounted assemblies with factory-fabricated and installed piping.

## PART 2 - PRODUCTS

### 2.1. PERFORMANCE REQUIREMENTS

A. Domestic water piping and components shall be capable of withstanding 80 psig at 75 °F. Piping systems shall be pressure tested, leak tested, flushed, and disinfected:

### 2.2. COPPER TUBE AND FITTINGS

A. Drawn-Temper (“Hard”) Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper (“Soft”) Copper Tubing: ASTM B 88, Type K.

C. Wrought-Copper Fittings and Unions: ASME B16.22.

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

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

## 2.3. JOINING MATERIALS

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

## 2.4. DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating non-conductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions, 2-inches NPS and smaller: Factory-fabricated ASSE 1079 rated for 150 psig at 180 °F with solder-joint copper alloy and threaded ferrous end connections.

# PART 3 - EXECUTION

## 3.1. PIPING APPLICATIONS

A. Domestic Water Piping, Above Ground:

1. Copper Piping: Type L, drawn-temper (“hard”) copper tubing, wrought-copper fittings and soldered joints.

B. Domestic Water Piping, Below Slab:

1. Copper Piping: Type K, annealed-temper (“soft”) copper tubing, wrought-copper fittings, and soldered joints. No joints shall be located below grade.

## 3.2. PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install shutoff valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 05 19 and with requirements for drain valves and strainers in Section 22 11 19.

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

E. Install domestic water piping level and plumb.

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

G. 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.

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

I. Install piping to permit valve servicing.

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

K. Install piping free of sags and bends.

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

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

N. Install piping to permit valve servicing.

O. Install piping to allow application of insulation.

P. Select system components with pressure rating equal to or greater than system operating pressure.

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

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

S. Install pressure gages on suction and discharge piping for each plumbing pump.

T. Install thermostats in hot-water circulation piping.

U. Install thermometers on inlet and outlet piping from each water heater.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17.

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17.

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

3.3. DIELECTRIC FITTING INSTALLATION

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

1. Piping 4-inches NPS and Smaller: Dielectric nipples or unions.

3.4. HANGERS AND SUPPORTS

A. Comply with requirements in Section 22 05 29 for hanger, support, anchor devices, and maximum spacings.

1. Straight Lengths of 100 Feet of Less: Adjustable clevis hangers.

2. Straight Lengths of Greater than 100 Feet: Adjustable roller hangers.

3.5. PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.6. CONNECTIONS

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

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve.

3.7. IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 05 53.

B. Label pressure piping with system operating pressure.

3.8. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

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

b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.

2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections make required corrections and arrange for reinspection.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

d. Cap and subject piping to static water pressure of 100 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

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

C. Prepare test and inspection reports.

3.9. 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.

3.10. CLEANING

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

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.

d. Repeat procedures if biological examination shows contamination.

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

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

3.11. 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: Brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, shall be the following:

1. Soft copper tube, ASTM B 88, Type K wrought-copper, solder-joint fittings; and brazed joints.

E. Aboveground domestic water piping, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; cast or wrought-copper, solder-joint fittings; and brazed joints.

3.12. VALVE SCHEDULE

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

1. Shutoff Duty: Use ball valves for piping 2-inches NPS and smaller.

2. Drain Duty: Hose-end drain valves.

END OF SECTION

# SECTION 22 11 19 – DOMESTIC WATER PIPING SPECIALTIES

## GENERAL

### 1.1. SUMMARY

A. Section includes special duty valves and specialties for domestic water piping systems.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

B. Closeout Submittals:

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

## PART 2 - PRODUCTS

### 2.1. GENERAL REQUIREMENTS

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

### 2.2. PERFORMANCE REQUIREMENTS

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

### 2.3. VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers: ASSE 1011, non-removable bronze body with manual seal, finish to match hose bib, and ASME B1.20.7 garden-hose threaded end.

### 2.4. BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Standard: ASSE 1013.

2. Operation: Continuous-pressure applications.

3. Pressure Loss: 12 psig maximum, through middle third of flow range.

4. Size: As noted on drawings.

5. Body: Bronze for NPS 2 and smaller; stainless steel or cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.

6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

7. Accessories:

   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.

   b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Hose-Connection Backflow Preventers:

1. Standard: ASSE 1052.

2. Operation: Up to 10-foot head of water back pressure.

3. Inlet Size: NPS 1/2 or NPS 3/4.

4. Outlet Size: Garden-hose thread complying with ASME B1.20.7.

5. Capacity: At least 3-gpm flow.

C. Backflow-Preventer Test Kits:

1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5. STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.

2. Body: Bronze for NPS 2 and smaller.

3. End Connections: Threaded for NPS 2 and smaller.

4. Screen: Stainless steel with round perforations unless otherwise indicated.

5. Perforation Size:

   a. Strainers 2-inches NPS and Smaller: 0.020-inch.

6. Drain: Threaded outlet with plug.

2.6. HOSE BIBBS

A. Hose Bibbs: ASME A112.18.1 with bronze body with replaceable bronze seat, 3/4-inch threaded or solder-joint supply connection, and ASME B1.20.7 garden-hose thread. Rated for 125 psig. Include operating key with each operating-key hose bibb

1. Vacuum Breaker: Integral or non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.

2. Finish:

    a. Equipment Rooms: Rough bronze, or chrome plated.

    b. Service Areas: Rough bronze Chrome plated.

    c. Finished Rooms: Chrome or nickel plated.

3. Operation:

    a. Equipment Rooms: Wheel handle or operating key.

    b. Service Areas: Wheel handle or Operating key.

    c. Finished Rooms: Operating key.

4. Include operating key with each operating-key hose bibb.

5. Include integral wall flange with each chrome- or nickel-plated hose bibb.

## 2.7. WALL HYDRANTS

A. Non-Freeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed outlet, self-draining wall hydrants.

2. Pressure Rating: 125 psig.

3. Operation: Loose key.

4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.

5. Inlet: NPS 3/4.

6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

7. Box: Deep, flush mounted with cover.

8. Box and Cover Finish: Polished nickel bronze.

9. Operating Keys(s): One with each wall hydrant.

## 2.8. DRAIN VALVES

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

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

## PART 3 - EXECUTION

### 3.1. INSTALLATION

A. Comply with requirements for ground equipment in Division 26.

### 3.2. FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION

# SECTION 22 13 16 – SANITARY WASTE AND VENT PIPING

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes pipe and fitting materials and joining methods for sanitary waste and vent piping.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

## PART 2 - PRODUCTS

### 2.1. PERFORMANCE REQUIREMENTS

A. Sanitary waste and vent piping and components shall be capable of withstanding 10-feet head of water at 75 °F in gravity systems. Piping systems shall be pressure tested, leak tested, and flushed.

### 2.2. PIPING MATERIALS

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

B. 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.

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

A. Pipe and Fittings: ASTM A 74, Service class. Hub and spigot cast iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A 74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.

B. Gaskets: ASTM C 564, rubber.

### 2.4. HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: Hub-less cast iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A 888 and CISPI Standard 301. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.

B. Heavy-Duty, Hubless-Piping Couplings: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop. Comply with ASTM C 1277 and ASTM C 1540.

## PART 3 - EXECUTION

### 3.1. EARTH MOVING

A. Comply with requirements of Division 33.

### 3.2. PIPING APPLICATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size and other design considerations.

2. 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. Make changes in direction for sanitary waste and vent piping using appropriate branches, bends, and long-sweep bends.

1. 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.

2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

   a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.

4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

   a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.

2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

3. Maintain swab in piping and pull past each joint as completed.

L. Install sanitary waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.

2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping. Comply with requirements for cleanouts specified in Section 22 13 19.

2. Install drains in sanitary waste gravity-flow piping. Comply with requirements for drains specified in Section 22 13 19.

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

O. Install sleeves for piping penetrations of walls, ceilings, and floors.

P. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

## 3.3. JOINT CONSTRUCTION

A. 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.

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

3.4. HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29.

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.

2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.

3. Vertical Piping: MSS Type 8 or Type 42, clamps.

4. Install individual, straight, horizontal piping runs:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

   b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

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

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

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

1. 1-1/2 and 2-inches NPS: 60 inches with 3/8-inch rod.

2. 3-inches NPS: 60 inches with 1/2-inch rod.

3. 4 to 5-inches NPS: 60 inches with 5/8-inch rod.

4. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

3.5. 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 waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste 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 waste and vent piping in sizes indicated, but not smaller than required by plumbing code.

4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

3.6. IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 22 05 53.

3.7. FIELD QUALITY CONTROL

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

   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in 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. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection make required corrections and arrange for re-inspection.

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

D. Test sanitary waste 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 waste 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 waste and vent piping except outside leaders on completion of roughing-in.

      a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.

b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.

c. 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.

a. 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.

b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.

c. Air pressure must remain constant without introducing additional air throughout period of inspection.

d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.8. CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping 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.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.9. PIPING SCHEDULE

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

B. Aboveground, sanitary waste and vent piping shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.

C. Underground, sanitary waste and vent piping shall be any of the following:

1. Service class, cast-iron soil piping; and gasketed joints.

END OF SECTION

# SECTION 22 1319 – SANITARY WASTE AND VENT PIPING SPECIALTIES

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes piping specialties for sanitary waste and vent piping.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

### 1.3. QUALITY ASSURANCE

A. Pipe materials shall bear label or other markings of specified testing agency.

## PART 2 - PRODUCTS

### 2.1. ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

### 2.2. CAST-IRON FLOOR DRAINS

A. Cast-Iron Floor Drains: ASME A112.6.3. Pattern: Area drain, Gray iron body with seepage flange and clamping de-vice. Floor drains for installation in floor not having membrane waterproofing may have seepage flange without clamping device. Bottom outlet. Heavy duty bronze strainer.

1. General: Size outlets as indicated on the drawings.

### 2.3. CLEANOUTS

A. Cast-Iron Exposed Cleanouts: ASME A112.36.2M for cast iron cleanout and test tee. Size: Same as connected drainage piping. Body material shall be hubless, cast-iron soil pipe test tee as required to match connected piping with a countersunk head plastic plug. Closure Plug Size: Same as cleanout size.

B. Cast-Iron Exposed Floor Cleanouts: ASME A112.36.2M for adjustable housing cleanout. Sized the same as connected branch. Cast iron body with spigot outlet connection and plastic plug. Adjustable Housing shall be Cast iron with threads. Frame and Cover Material and Finish: Painted cast iron with round cover. Medium Duty top loading classification and an ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts: ASME A112.36.2M. Include wall access. Size: Same as connected drainage piping. Hub-less, cast-iron soil pipe test tee as required to match connected piping. Countersunk cast iron plug with plug size same as cleanout size. Wall Access: Round, flat, stainless-steel cover plate with screw.

## PART 3 - EXECUTION

### 3.1. INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to 4-inches NPS. Use 4-inches NPS for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 180 degrees.
3. Locate at minimum intervals of 100 feet for horizontal piping runs.
4. Locate at base of each vertical sanitary waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Division 7.

E. Install through-penetration firestop assemblies in accordance to the requirements in Section 22 05 00.

F. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

G. Install sleeves with each riser and stack passing through floors with waterproof membrane.

H. Install wood-blocking reinforcement for wall-mounting-type specialties.

### 3.2. CONNECTIONS

A. Comply with requirements in Section 22 13 16 for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3. FLASHING INSTALLATION

A. Comply with requirements in Division 7.

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10-inches, and skirt or flange extending at least 8-inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.

3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement. For membrane roofs coordinate adhesive requirements with roofing contractor. Use adhesives compatible with roofing material.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counter-flashing or commercially made flashing fittings, according to Division 7.

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5. PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

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

END OF SECTION

# SECTION 22 14 16 – FUEL GAS PIPING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes fuel gas piping, specialties, and accessories within the building.

### 1.2 PROJECT CONDITIONS

A. Gas System Pressures: Pressure is reduced to secondary pressure of 0.5 psig or less downstream of the utility provided meter.

B. Design values of fuel gas supplied for these systems are as follows:
   1. Nominal Heating Value: 1000 Btu/cu. ft.
   2. Nominal Specific Gravity: 0.6.

### 1.3 SUBMITTALS

A. Product Data: For the following:
   1. Pressure regulators. Include pressure rating, capacity, and settings of selected models.

B. Shop Drawings: For fuel gas piping. Include plans and attachments to other Work.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

D. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.

### 1.4 QUALITY ASSURANCE

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

B. ANSI Standard: Comply with ANSI Z223.1, "National Fuel Gas Code."

C. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

D. IAS Standard: Provide components listed in IAS's "Directory of AGA and CGA Certified Appliances and Accessories" if specified to be IAS listed.

E. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

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

2.3 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

A. Steel Pipe: ASTM A 53; Type E or S; Grade B; Schedule 40; black.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
3. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
4. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
5. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.

B. Common Joining Materials: Refer to Division 22 Section "Basic Plumbing Materials and Methods" for joining materials not in this Section.

## 2.4 PROTECTIVE COATING

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

## 2.5 SPECIALTY VALVES

A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig minimum pressure rating.

C. Gas Valves, NPS 2 and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating.
1. Tamperproof Feature: Include design for locking.

## 2.6 CONCRETE BASES

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

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.

B. Comply with ANSI Z223.1, "Prevention of Accidental Ignition" Paragraph.

3.2 SERVICE ENTRANCE PIPING

A. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.
   1. Natural gas distribution system piping, service pressure regulator, and service meter are by gas company.

B. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting.

3.3 CONCRETE BASE INSTALLATION

A. Locate bases at service meters and service regulators.

B. Excavate earth and make level beds to support bases. Set bases level with top surface projecting approximately 3 inches above grade.

3.4 PIPING APPLICATIONS

A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Fuel Gas Piping, 0.5 psig or Less: Use the following:
   1. NPS 1/2 and Smaller: NPS 3/4 steel pipe, malleable-iron threaded fittings, and threaded joints.
   2. NPS 3/4 to 4: Steel pipe, malleable-iron threaded fittings, and threaded joints.
   3. Larger Than NPS 4: Steel pipe, steel welding fittings, and welded joints.

3.5 VALVE APPLICATIONS

A. Piping Line Valves, NPS 2 and Smaller: Gas valve.

3.6 PIPING INSTALLATION

A. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

B. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.

C. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

D. Connect branch piping from top or side of horizontal piping.

E. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

F. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.

G. Install pressure gage downstream from each line pressure regulator.

H. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

I. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches outside building and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar, epoxy-polyamide paint according to SSPC-Paint 16.

## 3.7 JOINT CONSTRUCTION

A. Use materials suitable for fuel gas.

## 3.8 HANGER AND SUPPORT INSTALLATION

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

## 3.9 CONNECTIONS

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

B. Install piping adjacent to appliances to allow service and maintenance.

C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches of each appliance. Install union downstream from valve.

D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

E. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
   2. Do not use gas pipe as grounding electrode.

## 3.10 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator, and specialty valve.

1. Text: In addition to name of identified unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.11 PAINTING

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

3.12 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.13 ADJUSTING

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

END OF SECTION

# SECTION 23 01 00 – HVAC GENERAL WORK REQUIREMENTS

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. DEFINITIONS

A. Owner Acceptance for Beneficial Occupancy: Work that is judged by the Engineer to be substantially complete, accepted to be safe for use by the Authority Having Jurisdiction (AHJ), and accepted by the Owner. Acceptance comes with an agreement the Engineer's written punchlist of outstanding items will be completed to fulfill the contractual obligations.

B. Full Owner Occupancy: Owner will occupy the site and existing building during entire construction period.

C. Partial Owner Occupancy: Owner may occupy completed areas of building before Owner Acceptance.

D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

E. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

F. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

G. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

H. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

I. Provide: Contractor shall furnish and install materials, equipment or fixtures as indicated.

J. Install Items Furnished by Owner or Others: Contractor shall receive shipment, store, install and verify materials, equipment or fixtures selected and purchased outside of the prime construction contract as indicated.

K. Furnish Items to Owner or Others: Contractor shall purchase and deliver materials, equipment or fixtures for installation by others as indicated.

### 1.3. SUBMITTALS

A. Qualification Submittals:

1. Welding certificates.

B. Product Submittals:

1. Wall and ceiling access door product information.

C. Construction Submittals:

1. Manufacturer startup, operation and maintenance checklists for all equipment and devices included in Division 23 specifications in a single submittal package for review prior to equipment startup.

D. Closeout Submittals:

1. Manufacturer startup, operation and maintenance reports with completed checklists signed by the involved technicians and the Mechanical Contractor’s witnessing superintendent.

1.4. INSPECTIONS

A. Contractor shall be responsible for obtaining all inspections from regulatory agencies having jurisdiction over the project. These inspections include but are not limited to: NC Department of Labor - NCDOL Boiler Safety Bureau for boilers and pressure vessels, NC Department of Insurance NCDOI, NC State Construction Office NCSCO, and other Local, State, and Federal inspection authorities as applicable.

1.5. QUALITY ASSURANCE

A. Welding Qualifications:

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

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

C. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

E. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

## 1.6. WARRANTY

A. Project Warranty: All work performed and all materials installed in Division 23 shall be warrantied by the Contractor for 1 year from the Owner's written acceptance of Owner Acceptance. The warranty shall include all labor and parts. The Contractor shall be on site within 48 hours of Owner notifications.

1. This warranty does not waive the Owner's obligation to provide routine maintenance. Routine maintenance includes maintenance recommended by each equipment manufacturer and industry standard requirements for overall systems as documented in the project's Operation and Maintenance Manuals. Replacement of wear items such as filters, belts, etc. are not included in the warranty unless they are incidental to other warranty work being performed. Failures due to the lack of routine maintenance are the responsibility of the Owner.

2. Equipment manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the obligations of the Project Warranty.

3. Extended or special warranties defined in other sections shall be in addition to, and run concurrently with, the Project Warranty.

## 1.7. PROJECT DOCUMENTS

A. Project Documents: Division 23 project documents are diagrammatic in nature and intended to represent complete and functioning systems. If any aspect of the work is undefined or unclear, submit your questions in writing prior to the final addendum deadline as defined in the specifications and/or at the pre-bid conference. If any aspect of the work is undefined or unclear after the final addendum, include the cost for the highest quality solution. The contractor is encouraged to thoroughly review the contract documents and site conditions prior to bidding.

B. Basis of Design Manufacturers: Manufacturer names and model numbers of equipment and devices noted on drawings and in equipment schedules shall be considered the Engineer's basis of design. Proposed changes to the basis of design shall be submitted to the Engineer for review and approval. The submittal shall include a description of all changes necessary to implement the substitution, including but not limited to plumbing, mechanical and electrical connections; dimensions, weights and structural supporting structure; layout changes necessary to maintain clearances; and acoustical treatments. All changes required to implement a substitution is the responsibility of Contractor at no added cost to the Owner.

C. Listed Manufacturers: Manufacturers listed in the Division 23 specification sections and on drawings must meet all the requirements of the project documents. <u>Listed manufacturers that do not meet the requirements will not be accepted</u>. The manufacturer listing does not result in an automatic approval. In addition to construction and performance requirements, the proposed equipment must meet the indicated physical dimension, weight, acoustic, power, controls, and plumbing limitations of the project. Verify existing conditions in the field, when applicable, and proposed conditions prior to submitting equipment for Engineer review. When full project coordination drawings are not required, generate coordination drawings to the level of detail necessary to determine if the proposed equipment will comply with the project documents and manufacturer recommended maintenance clearances.

1. If a manufacturer's equipment does not meet the physical dimension, weight, acoustic, power, controls and plumbing limitations of the project, a change order proposal may be submitted for the Owner's and Engineer's consideration. The proposal shall include all changes, including other trades, required and a reduction in cost to accept the non-conforming equipment. The base bid shall include equipment that fully meets the design requirements at no additional cost.

1.8. COORDINATION

A. Maintenance Access: Install equipment and devices in such a manner to be readily accessible for testing, adjusting, balancing, inspection and maintenance. All concealed equipment and devices, including but not limited to equipment, valves, dampers, actuators, sensors, gauges, test ports, filter housings, coils, etc., shall be installed above accessible ceilings, within accessible rooms or chases or within normally inaccessible construction with access doors. All access doors are not shown in the project drawings. All access doors shall be coordinated with the Engineer prior to the installation of the equipment or device. Equipment and/or devices not coordinated prior to installation, as judged by the Engineer, shall be removed and reinstalled at no added cost.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

1.9. VOC CONTENTS

A. Low Volatile Organic Compounds (VOC) Requirements: All adhesives, mastics, sealants and compounds factory or field applied that are installed indoors and all paint field applied shall be certified as low VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1. Adhesives: 50 g/L or less, except 80 g/L or less for calcium silicate and mineral fiber insulation and 30 g/L or less for metal-to-metal adhesives.

2. Mastics: 50 g/L or less.

3. Sealants: 250 g/L or less for duct sealants and 420 g/L or less for equipment insulation joint sealants.

4. Compounds: 490 g/L or less for CPVC welding compounds and 510 g/L or less for PVC welding compounds.

5. Paints: 50 g/L or less for flat paints and primers and 150 g/L or less for non-flat paints.

## PART 2 - PRODUCTS

### 2.1. PAINTS AND PRIMERS

A. General: Provide primers and paints designed for the intended applications. All primers and paints used indoors shall be low-odor and low VOC content type.

B. Primers:

1. Metal Applications: Water-based rust-inhibitive primer.
2. Aluminum Applications: Quick-drying primer for aluminum.
3. Wood Applications: Latex-based wood primer.
4. Interior Applications: Interior latex primer/sealer.

C. Paints:

1. Interior Applications: High-performance interior latex.
2. Exterior Applications: Exterior latex.
3. Match gloss level to adjacent finishes when applicable. Flat gloss level for all other applications, unless otherwise indicated.

### 2.2. CONCRETE MATERIALS

A. Concrete: Use the following unless otherwise indicated:

1. Equipment Housekeeping Pads: Light-weight aggregate with 3000 psi, 28-day minimum compressive strength.
2. Miscellaneous Uses: Medium-weight aggregate with 4000 psi, 28-day minimum compressive strength.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

C. Welded Wire Steel Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

### 2.3. GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

B. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

## 2.4. PATCHING MATERIALS

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

B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

## 2.5. ESCUTCHEONS AND FLOOR PLATES

A. Escutcheons:

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

B. Floor Plates:

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

## 2.6. ACCESS DOORS AND FRAMES, WALLS AND CEILINGS

A. Flush Access Doors with Concealed Flanges: Sheet steel door and frame, minimum 16-gauge, with face of door flush with frame, concealed flange and hinge, and key-operated lock and latch bolt.

1. Finish: Factory-painted flat white for white ceiling and wall surfaces. Factory-primed for field painted surfaces.
2. Coordinate frame styles with ceiling and wall types.
3. Fire and Smoke-Rated Access Doors and Frames: Access doors located within fire and smoke-rated walls and ceilings shall be self-closing, listed and labelled by a qualified testing agency and comply with NFPA 80. Ratings shall meet or exceed the rating of the adjacent construction.

# PART 3 - EXECUTION

## 3.1. DOCUMENTATION OF PROJECT CONDITIONS

A. Project Conditions: Document in digital-format photos and video the existing project conditions and continue to document the conditions as the project progresses. Owner claims of contractor damage will be judged by the documented conditions.

## 3.2. OPERATION AND MAINTENANCE MANUALS

A. The contractors shall deliver one complete set of bookmarked manuals in electronic PDF format of all operation and maintenance manuals to the Owner through the Designer, two (2) weeks before the pre-final inspection is held. The manuals shall be bookmarked to a minimum of one level – ie: each major piece of equipment (chiller, boiler switchboard, water closet, water heater, etc.) or document category (warranties, parts list, contact information, etc.) The manuals shall be delivered by one of the following:

1. USB Drive
2. CD/DVD
3. Downloadable file from FTP Site

B. Manuals shall include the following (at a minimum):

1. Index and page numbers
2. Certificate of Owner Acceptance
3. Summary sheet of warranties with dates noted and a copy of all warranties
4. List of all subcontractors and suppliers with names, addresses, and phone numbers
5. Special Inspection Reports
6. Certified Test and Balance Report
7. Complete start-up, operation, and shutdown procedures for each system including sequence of events, locations of switches, emergency procedures, and any other critical items.
8. Lubrication schedules and types of lubricants
9. Complete set of all submittal data and current shop drawings (including 3rd party generated shop drawings) and equipment description showing all capacities and other operation conditions.
10. Equipment summary showing all capacities and ratings (HP, Tons, kW, filter size, etc.).

## 3.3. OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. The Prime Contractor shall provide temporary heating, ventilation and air-conditioning as needed for the construction process. <u>Use of the permanent HVAC is prohibited</u>.

B. Permanent HVAC systems and components may only be operated for verification, testing, adjusting and balancing.

C. Owner/Engineer shall approve project conditions prior to system start-ups. Request start-up inspection minimum of 2 weeks prior to proposed start. Proposed start shall be coordinated with Owner's/Engineer's schedule.

D. Air System Temporary Operation: Systems shall only be operated when the building is completely enclosed, is clean and there are no dust or fume creating activities being performed.

1. Filtration: Prior to starting air systems, verify clean filters are installed in all air system equipment and clean temporary filter media is installed on all air intakes. Replace temporary filters on a regular basis. Provide minimum MERV-8 temporary filter media and comply with Section 234100. Replace all filters with new prior to Owner acceptance.

2. Air System Equipment Cleaning: Clean inside of air system equipment and install filters.

3. Air Handling Unit Control: The goal of construction conditioning is to remove excessive humidity to allow the installation of finishes. It is not to meet building design temperature.

a. Air handlers should be started initially at 100-percent outside air. Outside air intakes shall have a double layer of blue roll filter media, either at the outside air intake louvers or directly inside the unit prior to prefilters. If outside air intakes are going to be exposed to dust and dirt from site construction, consideration should be made to temporarily relocate intake by ducting to an elevation where the intake is protected from dirt and dust. Roll filter media should be periodically monitored for build-up and replaced as necessary. Do not operate unit while changing filters.

b. If systems do not have 100-percent outside air capability and return duct must be utilized, all return openings must be filtered to prevent contaminating the duct system and equipment.

c. When using return air, do not close outside air damper completely. Balance outside air flow to 10 to 20-percent of total flow to maintain positive pressure in the building.

E. Owner/Engineer must approve operation of the permanent HVAC systems for use at Owner Acceptance.

3.4. WELDING AND BRAZING

A. Medium and High Pressure Piping (Above 15 psig):

1. Fabrication:

a. Medium and high pressure steam and heating water piping systems shall be fabricated, assembled and welded in accordance with ASME B31.1, and Power Piping Codes PFI ES 1, PFI ES 3, PFI ES 7, PFI ES 21, PFI ES 31, PFI ES 35, and PFI TB1 of the Piping Fabrication Institute's companion code requirements.

b. Other high pressure piping systems shall be fabricated, assembled and welded/brazed/ soldered in accordance with ASME B31.3, and Power Piping Codes PFI ES 1, PFI ES 3, PFI ES 7, PFI ES 21, PFI ES 31, PFI ES 35, and PFI TB1 of the Piping Fabrication Institute's companion code requirements.

c. Refrigeration piping systems shall be fabricated, assembled and welded/brazed in accordance with the ASME B31.5.

2. Non-Destructive Inspection and Testing: All pipe welds shall be tested by a qualified, Engineer approved, testing agency at the expense of the contractor.

B. Low Pressure Piping (15 psig and lower):

1. Fabrication:

a. Copper make-up water and drainage piping systems shall be fabricated, assembled and soldered in accordance with ASTM B828.

b. Other low pressure piping systems shall be fabricated, assembled and welded/brazed in accordance with the ASME B31.9.

2. Non-Destructive Inspection and Testing: Engineer shall visually inspect pipe welds. Based on visual inspections, upon order of the Engineer, non-destructive testing of selected pipe welds shall be performed by a qualified testing agency, at the expense of the Owner, using one of the following methods selected by the Engineer. The welds inspected shall be selected randomly, but the selection shall include an examination of welds made by each welding operator or welder.

3.5. PAINTING

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.

B. Clean substrates of substances that could impair bond of paints, including dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and re-prime substrate with compatible primers as required to produce paint systems indicated.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

D. Painting of Division 23 Work: Paint items exposed in equipment rooms and occupied spaces including, but not limited to, the following:

1. Visible portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets.

2. Duct, equipment, and pipe insulation having cotton, canvas or metal insulation covering or other paintable jacket material as required by Section 230553 and elsewhere as indicated.

3. Mechanical equipment that is indicated to have a factory-primed finish for field painting.

E. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.

F. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6. CONCRETE

A. Design, construct, erect, brace, and maintain formwork according to ACI 301.

B. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

C. Comply with ACI 301 for measuring, batching, mixing, transporting, and placing concrete.

D. Equipment Concrete Bases: Housekeeping pads shall match the indicated dimensions but not be less than required to extend 4-inches beyond the equipment footprint in each direction and have chamfered edges.

1. Concrete Base Depths:

   a. Air Handling Units: Minimum 6-inches thick, unless otherwise indicated.

   b. HVAC Equipment: Minimum 4-inches thick, unless otherwise indicated.

2. 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 the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.7. GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8. WALL, FLOOR AND ROOF OPENINGS

A. Exterior and interior wall, floor and roof openings made for duct, piping and conduit penetrations shall maintain the building's structural integrity. Install penetration sleeves, framing and lintels in accordance with the structural engineer.

3.9. REPAIR AND PATCHING

A. Repair damage created during the construction process. Repair quality shall be equal to or better than original condition as judged by the Architect/Engineer.

B. Patch wall, floor and roof openings created by removal of mechanical system items during the construction process. Patch and finish with materials consistent with adjacent finishes and materials.

1. Openings in fire /smoke rated assemblies shall be patched per UL-listed detail.

C. Identify and document existing building damage and openings in walls, floor and roof that are outside the project scope prior to the start of work. Report them promptly to the Architect/Engineer.

3.10. ACCESS DOOR INSTALLATION

A. Coordinate the need and exact location of each access door with Architect/Engineer prior to installation.

B. Center wall and ceiling access doors on duct access doors, valve centers, junction boxes, etc. to provide the best access to inspect, operate, and maintain the associated mechanical and electrical devices.

C. Install wall and ceiling access doors level and square to building surfaces. Comply with manufacturer's written instructions.

D. Install access doors such that their door swings are not blocked from opening fully and they open in the direction that provides the best access for the user.

E. Adjust doors and hardware for proper installation.

F. Touch-up door finishes with factory-provided paint as needed prior to completion.

G. Verify fire and smoke-rated door labels have not been painted over in the field.

H. Label wall and ceiling access doors with clear plastic ceiling tags in compliance with Section 23 05 53.

3.11. PIPING SYSTEM INSTALLATION GENERAL REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

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

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs. Refer to Section 230517 for more information about sleeves and sleeve seals.

M. Verify final equipment locations for roughing-in.

N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

O. Piping Connections: Make piping connections according to the following unless otherwise indicated:

1. Install unions, in piping 2-inches NPS and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping 2-1/2 inches NPS and larger, adjacent to flanged valves and at final connection to each piece of equipment.

## 3.12. ESCUTCHEONS AND FLOOR PLATES INSTALLATION

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

B. Install escutcheons with inside diameter to closely fit around pipe, tube, and insulation of piping and with outside diameter that completely covers opening.

1. New Piping: Install one-piece cast-brass type for new piping installations. Install deep-pattern type where piping sleeve protrudes from the floor or wall.

2. Existing Piping: Install split-casting brass type for existing piping installations.

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

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

1. New Piping: One-piece, floor-plate type.

2. Existing Piping: Split-casting, floor-plate type.

E. Replace broken and damaged escutcheons and floor plates using new materials.

## 3.13. EQUIPMENT INSTALLATION GENERAL REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

## 3.14. ADDITIONAL CONSTRUCTION PROCEDURES

A. General Requirements: In addition to the requirements of Division 1 and individual Division 23 sections, the Contractor shall comply with the following requirements during project construction:

1. Bidding: Review the requirements in the entire set of bid documents. Review the Project Documents paragraphs in Part 1 of this section. Submit clarification questions in compliance with Division 1 and Division 23.

2. Submittals: Submit delegated design, qualification, product, construction and close-out submittals required in each Division 23 section. Utilize the Submittal List in Section 230110 to verify each submittal has been submitted and reviewed prior to the installation of related equipment and materials.

3. Reference Documents: Maintain a hard copy set of Division 23 bid documents and submittals for reference in the on-site project office. Mark documents to record installed conditions and tested duct and piping.

   a. Duct and Pipe Pressure and Leakage Testing: Upon successful completion of testing each section of duct and pipe, number, highlight, date and initial the tested sections. The section numbers shall match in the testing report. Each tested section shall be initialed by an appropriate representative from the Contractor and Owner / Commissioning Agent or Engineer.

   b. Life-Safety Dampers: Successfully tested life-safety dampers shall be highlighted and initialed by an appropriate representative from the Contractor and Owner / Commissioning Agent or Engineer.

4. Stored Material Verification: In coordination with each monthly Owner Construction Coordination Meeting, provide a copy of the month's proposed Payment Application and access to all equipment or material stored in an off-site insured and bonded warehouse for verification meeting the requirements of Division 1. Payment Applications with unverified off-site stored equipment and materials will not be approved.

5. Pre-Installation and Testing Meetings: Schedule Pre-Installation Meetings required in Division 23 sections with the Owner / Commissioning Agent and Engineer.

6. Equipment Start-Up: Schedule major equipment start-up procedures with the Owner / Commissioning Agent and Engineer.

END OF SECTION

SECTION 23 02 00 – HVAC SYSTEMS OWNER TRAINING

PART 1 - GENERAL

1.1. SUMMARY

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

1.2. SUBMITTALS

A. Construction Submittals:

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

B. Close-Out Submittals:

1. Training Attendance List.

2. Demonstration and Training Videos: Submit two copies within 14 days of the end of training program.

1.3. QUALITY INSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: A factory-authorized service representative experienced in operation and maintenance procedures and training.

C. Pre-Instruction Conference: Conduct conference at the project site. Review methods and procedures related to demonstration and training.

D. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.1. INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections, and as follows:

1. HVAC Control Systems
2. Motor Starters and Disconnect Switches
3. Fans, Supply, Return, Relief and Exhaust
4. Packaged Rooftop Units

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following:

1. Basis of System Design, Operational Requirements and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
3. Emergencies: Include instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.
4. Operations: Include startup, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.
5. Adjustments: Include alignments and checking, noise, vibration, economy, and efficiency adjustments.
6. Troubleshooting: Include diagnostic instructions and test and inspection procedures.
7. Maintenance: Include inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.
8. Repairs: Include diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

## PART 3 - EXECUTION

### 3.1. GENERAL REQUIREMENTS

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner with at least 30 days' advance notice.

D. Instruction Duration: Instructional time shall be no less than three (3) 8-hour days with an hour break for lunch, 8:00 am – 5:00 pm.

E. Document training attendance for each session.

3.2. DEMONSTRATION AND TRAINING VIDEOS

A. General: Engage a qualified commercial photographer to record demonstration and training videos. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids.

B. Video Format: Provide high-quality minimum 720p resolution MP4 video burned to DVDs or USB Flash Drives.

C. Narration: Describe scenes on video by audio narration by microphone while video is recorded. Include description of items being viewed.

END OF SECTION

# SECTION 23 05 11 – HVAC ELECTRICAL PROVISIONS

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals:

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

B. Close-Out Submittals:

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

### 1.3. QUALITY ASSURANCE

A. Source Limitations: Obtain motor starters, disconnect switches and combination motor starters and disconnect switches of a single type through one source from a single manufacturer.

1. Exceptions: Disconnect switches that are factory-mounted to HVAC equipment may be provided by the equipment manufacturer.

B. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

1. Where requirements of Division 23, Division 26 or NFPA 70 conflict, conform to the strictest requirements.

C. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

## 1.4. EXTRA MATERIALS

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

1. Fuses: One set for each fused device.

# PART 2 - PRODUCTS

## 2.1. EQUIPMENT ENCLOSURES

A. Provide NEMA-rated equipment enclosures for all disconnect switches, motor starters, control panels, variable speed controllers and other similar electrical equipment. When not otherwise indicated, provide enclosures based on the environments of the installations.

1. Inside, Clean Spaces without Water Piping: NEMA 1.
2. Inside, Utility Spaces and Spaces with Water Piping: NEMA 12.
3. Outside, Normal Ambient Conditions: NEMA 3R.

## 2.2. DISCONNECT SWITCHES

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

1. Eaton
2. ABB/General Electric
3. Schneider Electric/Square D
4. Siemens

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

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

D. Provide switch accessories required to meet the system requirements indicated.

2.3. MOTOR STARTERS

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

1. Eaton

2. ABB/General Electric

3. Schneider Electric/Square D

4. Siemens

B. Description: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system requirements indicated. Cover door shall have red and green pilot lights. The green light shall illuminate when “on”, and red shall illuminated when “off”.

2.4. COMBINATION MOTOR STARTERS AND DISCONNECT SWITCHES

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

1. Eaton

2. ABB/General Electric

3. Schneider Electric/Square D

4. Siemens

B. Description: Combination magnetic motor starter and circuit breaker disconnecting means with auxiliary contacts.

1. Disconnecting Means: Thermal magnetic type molded-case circuit breaker (MCCB) with adjustable instantaneous-trip for each pole, auxiliary control and monitoring contacts and test trip button.

2. Motor Starter: Full-voltage, electrically-held, non-reversing, magnetic motor controllers with 24Vac control circuit, hand-off-auto (HOA) switch, push-to-start switch, manual reset switch, auxiliary control and monitoring contacts and accessories required to meet the system requirements indicated. Cover door shall have red and green pilot lights. The green light shall illuminated when “on”, and red shall illuminated when “off”.

2.5. MANUAL MOTOR SWITCHES

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

1. Eaton
2. ABB/General Electric
3. Schneider Electric/Square D
4. Siemens

B. Description: Manual motor starter and disconnect switch with thermal overload protection for fractional horsepower motors. Toggle switch shall provide manual "on/off" control of one or two-pole single-phase motors rated up to 1 horsepower. The enclosure shall have green pilot light. The green light shall illuminate when "on". The switch shall have a hand guard to prevent accidental operation and provisions for a padlock in the "off" position. The switch shall be rated for single or two-speed applications as indicated. The enclosure shall be for flush wall-mounting where possible and surface wall-mounting where not.

## 2.6. FUSES

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

## 2.7. SHORT-CIRCUIT CURRENT RATINGS

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

## 2.8. POWER AND CONTROL CABLING AND RACEWAY

A. Low-Voltage (100 to 600 V) Power Feeders: Size conductors and raceway per NFPA 70 and Division 26 based on equipment nameplate requirements and manufacturer's installation recommendations.

B. Control-Voltage (Up to 24 V) Cabling: Provide control cabling for HVAC system per NFPA 70 and Division 26 based on the system manufacturer's installation recommendations.

1. Paired Cabling: No. 16 AWG Type CMP plenum-rated twisted pair.
2. Class 1 and 2 Control Circuits: Stranded copper Type THHN-THWN.
3. Class 3 Control Circuits: Stranded copper Type TW or TF.

C. Power Conductors: Copper, solid for No. 10 AWG and smaller and stranded for No. 8 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.

D. Grounding Conductors: Copper, solid for No. 8 AWG and smaller and stranded for No. 6 AWG and larger, with THHN-THWN insulation. Aluminum conductors will not be accepted.

E. Conduit:

1. EMT (electrical metallic tubing): Indoor, above-grade applications not subject to damage.
2. RGS (rigid galvanized steel): Indoor, above-grade applications subject to damage and outdoor, above-grade applications.
3. RNC (rigid non-metallic conduit), Type Schedule 40 PVC: Indoor and outdoor, below-grade applications. The elbow required and the stub-up out of the slab or earth shall be of rigid steel (RGS) for the last two feet minimum.
4. FMC (flexible metallic conduit): Indoor, above-ceiling applications. Permitted for final connections only.
5. LFMC (liquid-tight flexible metal conduit): Outdoor, above-grade applications. Permitted for final connections only.

## PART 3 - EXECUTION

### 3.1. INSTALLATION

A. Disconnect Switches: Provide disconnect switches for all HVAC equipment. Disconnect switches shall be sized to comply with NFPA 70. Single fan, blower and pump motors shall be based on nameplate horsepower. All other applications shall be based on nameplate total kW rating. Disconnects shall be provided with dual-element fuses sized based on equipment nameplate rating.

1. Service Disconnect Switches: Where the disconnecting means is not within the line-of-sight, as defined by NFPA 70 and the authority having jurisdiction (AHJ), an additional service disconnect shall be located adjacent to the equipment it feeds.

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

| **DISCONNECT SWITCH SIZES for EQUIPMENT** | | | | | | | |
|---|---|---|---|---|---|---|---|
| AMPERAGE RATING | MAX KW at VOLTAGE/PHASE | | | | | | |
| | 120V/1ph | 208V/1ph | 240V/1ph | 277V/1ph | 208V/3ph | 240V/3ph | 480V/3ph |
| 30A | 2.8 | 5.0 | 5.8 | 6.6 | 8.6 | 10.0 | 19.9 |
| 60A | 5.8 | 10.0 | 11.5 | 13.3 | 17.3 | 19.9 | 39.9 |
| 100A | 9.6 | 16.6 | 19.2 | 22.2 | 28.8 | 33.2 | 66.4 |
| 200A | 19.2 | 33.3 | 38.4 | 44.3 | 57.6 | 66.4 | 132.9 |
| 400A | 38.4 | 66.6 | 76.8 | 88.6 | 115.1 | 132.9 | 265.7 |
| 600A | 57.6 | 99.8 | 115.2 | 133.0 | 172.7 | 199.3 | 398.6 |

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

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

C. Combination Motor Starters and Disconnect Switches: Provide combination motor starters and disconnect switches that meet the requirements of the “Motor Starters” article above. Combination motor starters and disconnect switches shall be used unless otherwise noted or prohibited by NFPA 70.

D. Manual Motor Switches: Provide manual motor switches for fractional horsepower fan, blower and pump motors that do not require automated start and stop functions.

E. Furnish and install devise fuses per equipment unit nameplate.

F. Size and adjust circuit breaker disconnect switches per equipment unit nameplate.

G. Electrical Connections: All electrical connections shall be made in accordance with equipment manufacturer’s recommendations and in accordance with NFPA 70. Install and ground equipment connections in accordance with the requirements of NFPA 70 and Division 26.

1. Electrical Connections, Low Voltage (100 to 600 V): Division 23 contractor is responsible for power wiring and conduit from the equipment connections to the disconnecting means. Division 26 is responsible for the power circuit from the power source to the disconnecting means.

2. Electrical Connections, Control Voltage (Up to 24 V): Division 23 contractor is responsible for all control voltage wiring and conduit for HVAC equipment and controls from the low voltage power source disconnecting means. Division 26 is responsible for the low voltage power circuit from the power source to the disconnecting means.

   a. Low Voltage Disconnecting Means: Where dedicated low voltage circuits are indicated in Division 26 documents, the disconnecting means shall be defined as the disconnect switch or junction box provided. Where dedicated low voltage circuits are not explicitly indicated in Division 26 documents, the disconnecting means shall be defined as 20A/1P spare circuit breakers in panelboards.

H. Wiring Pathway, Low and Control Voltage: All low and control voltage power and control wiring shall be installed in conduit unless otherwise noted.

1. Surface-mounted raceway may only be used when indicated or Engineer approved prior to installation. In most cases, conduits shall be installed within walls, above ceilings and below floor slabs. Cut and repair substrates to install raceway.

2. Control voltage cabling shall be plenum-rated and organized with J-hooks when control cabling is not required by the Engineer to be installed in conduit.

I. Conduit:

1. Flexible Connections: Provide flexible connections for all vibrating equipment including fans, pumps, compressors, etc. Flexible connections shall be no more than 24-inches long.

2. Areas Subject to Damage: In areas where the conduit will be exposed and is subject to damage, such as mechanical equipment rooms, RGS conduit shall be installed to no less than 8-feet above finished floor and EMT may be used above 8-feet.

J. Grounding and Bonding: Ground and bond equipment and circuits in accordance with the requirements of NFPA 70 and Division 26.

K. Install duct-mounted smoke detectors, furnished and wired by Division 26. Provide duct access doors for proper maintenance and access.

L. Smoke-rated life-safety dampers shall be wired and controlled by Division 26.

M. Smoke control system devices shall be wired and controlled by Division 26.

3.2. FIELD QUALITY CONTROL

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

3.3. DEMONSTRATION

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

END OF SECTION

# SECTION 23 05 13 – HVAC EQUIPMENT MOTORS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes general requirements for all HVAC motors

### 1.2. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

## PART 2 - PRODUCTS

### 2.1. GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

C. Motors for fans and pumps shall be selected for the maximum brake-horsepower listed in the equipment schedules and no more than 85% of the nominal rated horsepower excluding the service factor.

### 2.2. MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea-level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

### 2.3. POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motors.

1. General Use: Open drip-proof (ODP) motors.

2. Cooling Towers:

a. Inside Air Stream: Totally enclosed over air (TEOA).

b. Outside Air Stream: Totally enclosed fan cooled (TEFC).

B. Efficiency: All motors shall be Premium Efficiency conforming to the requirements of NEMA MG1 Part 31. Conform to 10 CFR Part 431 published by the US Department of Energy - Efficiency standard for integral horsepower motors.

1. Minimum efficiency shall meet the requirements of the State Energy Conservation Code and ASHRAE 90.1.

C. Service Factor: 1.15.

1. Multispeed Motors: Variable torque.

2. For motors with 2:1 speed ratio, consequent pole, single winding.

3. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Class B.

G. Insulation: Class F.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

## 2.4. POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

2. Inverter-Duty Motors: Motors shall be "Inverter-Duty" rated according to NEMA MG 1 Part 31, "Requirements for Definite Purpose Inverter-Fed Polyphase Motors", with minimum Class F temperature rise and Class H insulation. NEMA duty rating code on motor nameplate shall indicate "Inverter-Duty". Other duty rating code markings such as "Inverter-Ready" are not acceptable.

3. Shaft Grounding Rings (SGR): Motors 5 hp and larger shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.

4. Thermal Protection: Comply with NEMA MG 1 Part 12.56, "Thermal Protection of Medium Motors" requirements for thermally protected motors, including a manual-reset type thermal protection device.

5. Shaft Grounding Rings (SGR): Multi-phase motors shall have solid or split type shaft grounding rings designed to prevent bearing damage due to adjustable speed drive induced currents. SGR shaft diameter shall match the motor's standard NEMA "u" dimension.

6. Over-Speeding: Variable frequency drives shall not be set above 60 Hz.

   a. Exceptions:

      1) Air Handling Units without Setback Schedules: Variable frequency drives shall not operate over 75 Hz and motors shall not operate over 3,000 RPM for direct-drive fans.

      2) Air Handling Units with Setback Schedules: Variable frequency drives shall not operate over 90 Hz and motors shall not operate over 3,000 RPM for direct-drive fans used in air handling units.

7. Under-Speed Operation: Motors shall be capable of continuous operation at minimum design operating speed indicated on the drawings. Where minimums are not indicated, motors shall be capable of continuous operation at the following minimum speeds.

   a. Fans: 18 Hz (30-percent).

   b. Pumps: 12 Hz (20-percent).

C. Electronically-Communicated (EC) Motors

1. Electronically-communicated (EC) motors, also known as brushless DC electric (BLDC) motors, shall be NEMA MG 1, totally enclosed fan cooled (TEFC), inverter-use, motors with integrated microprocessor speed controller designed for variable speed and torque fan and pump applications.

   a. Speed controller shall be programmed with safeties to avoid damaging conditions and unstable fan / pump operation. Firefighter's safety override mode shall allow bypass of most speed controller safeties.

   b. Speed controller shall comply with requirements of Section 230514.

2.5. SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

# SECTION 23 05 53 – HVAC SYSTEMS IDENTIFICATION

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Product Data: For each type of product indicated.
2. Samples: For color, letter style, and graphic representation required for each identification material and device.

B. Close-Out Submittals:

1. Valve Schedules: For each piping system to include in maintenance manuals.

### 1.3. COORDINATION

A. Coordinate the identification requirements with the Owner’s up-to-date standards prior to purchasing materials.

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 locations of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

## PART 2 - PRODUCTS

### 2.1. EQUIPMENT LABELS

A. Plastic Labels for Equipment: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch white letters on black background.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's drawing designation or unique equipment number.

2.2. WARNING SIGNS AND LABELS

A. Warning Signs and Labels: 1/8-inch multilayer, multicolor, plastic labels for mechanical engraving suitable for temperatures up to 160 deg F with pre-drilled holes for stainless steel rivets or self-tapping screws. Labels shall be minimum 2-1/2 inches wide and 3/4-inch tall with 3/8-inch letters.

1. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3. PIPE LABELS

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

2.4. DUCT LABELS

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

2.5. STENCILS

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

2.6. VALVE TAGS

A. Valve Tags: 0.032-inch thick brass or 0.025-inch thick stainless steel, stamped or engraved, with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers with pre-drilled or stamped holes for beaded chain or S-hook attachment hardware.

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. CEILING TAGS

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

2.8. WARNING TAGS

A. Warning Tags: 5-1/4 inches wide and 3-inches tall, pre-printed or partially pre-printed, accident-prevention tags, of plasticized card stock with matte finish suitable for writing, fastened with reinforced grommet and wire. Tags shall have letters with large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

2.9. SENSOR TAGS

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

PART 3 - EXECUTION

3.1. PREPARATION

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

3.2. JACKET COLOR

A. Piping and Piped Equipment Insulation Jacket: Paint or provided pre-colored jacketing for all piping system insulation jacket meeting the requirements of this section.

1. P/M/E Equipment Rooms: Color per System Identification Schedule.
2. Exposed-to-View: Color per System Identification Schedule.
3. Exposed-to-View: Flat Black.
4. Concealed: Not required.
5. Concealed: Color per System Identification Schedule.

B. Duct and Ducted Equipment Insulation Jacket: Paint or provided pre-colored jacketing for all duct system insulation jacket meeting the requirements of this section.

1. PME Equipment Rooms: Color per System Identification Schedule.
2. PME Equipment Rooms: Not required.
3. Exposed-to-View: Flat Black.
4. Exposed-to-View: Not required.
5. Concealed: Not required.

3.3. PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

3.4. EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment. Equipment to be labelled includes but is not limited to:

1. Air handling equipment, including AHU, BCU, FCU, RTU, DOAS, ERU, CRAC, etc.
2. Fans.
3. Heating and cooling coils.
4. Control panels and main sensors.
5. Variable speed controllers, motor starters and disconnects.
   a. Coordinate labeling with Division 26.

B. Central HVAC system equipment labels shall include capacity and design information. Submit proposed label information for Engineer approval. The following are examples:

1. Rooftop Units

   ROOFTOP UNIT RTU-1
   INSTALLED: JUNE 2030
   SERVICE: ADMINISTRATION AREA
   CAPACITY: 2,000 CFM at 1.0” ESP
   COOLING: 5 TONS
   HEATING: 25 KW

2. Fans

   EXHAUST FAN EF-1
   INSTALLED: JUNE 2030
   SERVICE: ROOM 201 FUME HOOD
   CAPACITY: 500 CFM at 0.5” ESP

C. Locate equipment labels where accessible and visible.

D. Equipment Color Schedule: Insulation color and label scheme shall match the associated piping system.

3.5. DUCT LABEL INSTALLATION

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

1. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1-inch high is needed for proper identification because of distance from normal location of required identification.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

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.

3.7. CEILING TAG INSTALLATION

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

3.8. WARNING-TAG INSTALLATION

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

3.9. SENSOR TAG INSTALLATION

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

3.10. RATED PENETRATION INSTALLATION

A. Stencil penetration ratings and UL detail numbers on wall surfaces directly adjacent to the penetrations. UL detail number shall match the material used. This information shall be readily visible in non-occupied spaces, within chases and above ceilings. The following is an example:

2-HR RATED FIRE BARRIER
UL DETAIL SYSTEM NO. ABC-0000

3.11. SYSTEM IDENTIFICATION SCHEDULE

A. Install equipment, piping and duct identification materials with the color and abbreviations that match the Owner's standard practice. Refer to System Identification Schedule below.

| **SYSTEM IDENTIFICATION SCHEDULE** | | | |
|---|---|---|---|
| PIPING SYSTEMS | ABBREV. | BACKGROUND | LETTERING |
| REFRIGERANT | REF | WHITE | BLACK |
| CONDENSATE DRAIN | CD | WHITE | BLACK |
| VALVE TAGS | | BRASS | BLACK |
| EQUIPMENT AND DUCT SYSTEMS | ABBREV. | BACKGROUND | LETTERING |
| GENERAL BUILDING AIR | SA/RA/EA/OA | WHITE | BLACK |
| WARNING SIGNS | SEE PLANS | SAFETY YELLOW | BLACK |
| CEILING GRID MARKERS | SEE PLANS | CLEAR | BLACK |
| EQUIPMENT TAGS | SEE PLANS | BLACK | WHITE |

NOTE: PROVIDE FLOW ARROWS ON ALL DUCT AND PIPE MARKERS.

END OF SECTION

# SECTION 23 05 93 – TESTING, ADJUSTING AND BALANCING

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes testing, adjusting and balancing (TAB) of building systems.

### 1.2. GENERAL DESCRIPTION

A. HVAC Air Systems:

1. Verify duct leakage tests and results.
2. TAB of new HVAC air systems including supply, return, exhaust, relief and outside air to design requirements.

B. HVAC Piping Systems:

1. Measuring and testing of existing HVAC piping systems including refrigerant prior to the start of work to determine the existing baseline performance.
2. Verify pipe leakage tests and results.
3. TAB of new HVAC piping systems including refrigerant to design requirements.

C. HVAC Control Systems:

1. Verify new HVAC control systems.

D. Plumbing Piping Systems:

1. TAB of new plumbing systems including domestic hot water recirculation to design requirements.

### 1.3. SUBMITTALS

A. Qualification Submittals:

1. Qualification Data: Within 30 days of the Notice to Proceed, submit documentation that the TAB contractor and the project's TAB team members meet the qualifications specified in "Quality Assurance".
2. Instrument calibration reports, to include the following: instrument type and make; serial number; application; dates of use; and dates of calibration.

B. Product Submittals: For each type of product indicated.

C. Construction Submittals:

1. Initial certified TAB reports of individual systems for engineer’s review.

D. Close-Out Submittals: Final certified TAB report with all systems in a single report.

1.4. QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).

1. TAB Field Supervisor: TAB contractor employee who is certified by AABC or NEBB.

2. TAB Technician: TAB contractor employee who is certified by AABC or NEBB.

B. TAB Conference: Meet with engineer, owner, construction manager, owner’s commissioning agent and related sub-contractors regarding the approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide 30-day notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.

b. The TAB Plan.

c. Coordination and cooperation of trades and subcontractors.

d. Coordination of documentation and communication flow.

C. TAB Certification: Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard AABC or NEBB report forms as reviewed by the engineer.

E. TAB Instrumentation: Provide instrumentation certification report including equipment type and make, serial number, accuracy and calibration as described in ASHRAE-111, Section 5, "Instrumentation."

1. All instruments shall be calibrated within 6 months of use.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing” and ASHRAE 90.1, Section 6.7.2.3 - "System Balancing”.

G. Code and AHJ Compliance: Comply with governing codes and requirements of authorities having jurisdiction.

1.5. PROJECT CONDITIONS

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

1.6. COORDINATION

A. Notice: Provide 10-day notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and hydronic systems have been satisfactorily completed. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous TAB results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.

1. Duct pressure tested without duct accessories such as dampers and access doors installed is not valid.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1. EXAMINATION

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

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

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

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

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment

performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

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

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

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

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

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

L. Examine control dampers for proper installation for their intended function of isolating, throttling, di-verting, or mixing air flows.

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

3.2. PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures including a list of each piece of equipment and system.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. General:

a. Permanent electrical-power wiring is complete.

b. Automatic temperature-control systems are operational.

c. Equipment and duct access doors are securely closed.

d. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

e. Windows and doors can be closed so indicated conditions for system operations can be met.

2. HVAC Air Systems:

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.

3. HVAC Piping Systems:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.

b. Systems are flushed, filled, and air purged.

c. Control valves are functioning in accordance with the sequence of operation.

d. Shutoff and balance valves have been verified to be 100 percent open.

e. Variable-frequency controllers startup is complete and safeties are verified.

f. 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 according to the procedures contained in ASHRAE-111 and in this Section.

1. Comply with requirements in ASHRAE-62.1, Section-7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300.

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to specifications.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4. GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Coordinate pullies and sheaves needed to balance applicable air systems with fan supplier. Refer to Section 233400.

E. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

F. 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.

G. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

H. Verify that motor starters are equipped with properly sized thermal protection.

I. Check dampers for proper position to achieve desired airflow path.

J. Check for airflow blockages.

K. Check condensate drains for proper connections and functioning.

L. Check for proper sealing of air-handling-unit components.

M. Verify that air duct system is sealed as specified.

3.5. PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.

   b. Measure static pressure directly at the fan outlet.

   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.

   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

E. 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.

3.6. PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.

3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

4. Readjust fan airflow for final maximum readings.

5. Measure operating static pressure at the sensor that controls the supply fan if one is installed and verify operation of the static-pressure controller.

6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.

3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation.

6. Measure static pressure at the sensor.

7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

E. Single-Zone, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set supply fan at minimum airflow if minimum airflow is indicated. Minimum airflow shall be not be below the minimum airflow requirements of the system for proper operation.
3. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
4. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
5. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.7. PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.8. PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure 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.

3.9. PROCEDURES FOR  HEATING COILS

A. 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.

3.10. PROCEDURES FOR REFRIGERANT COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.11. 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.

3.12. 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.

3.13. HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing and the BAS Controls Contractor, 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. Verify each control sequence of operation line-by-line including the operation of all equipment, valves dampers, etc.
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.

3.14. TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.15. 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. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB 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 indicated versus final performance; notable characteristics of systems; and 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 speed controller settings.
    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. Floor Plans: Include a copy of the ductwork plans, from either the Mechanical Contract Documents or Mechanical Contractor’s sheet metal fabrication documents, with final air flow values of all airside equipment and of each air inlet and outlet superimposed.

1. The floor plans are in addition to the written report. The values on the plans should match those in the written report and provide an easy reference to the location of each device.

E. 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. Balancing stations.
6. Position of balancing devices.

F. 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. Profile of internal pressure losses across each internal component, for example: fan, cooling coil, heating coil, filters, dampers, etc.

      1) Exception: Profiles are not required for air handling equipment with capacities of 5,000 cfm and smaller.

   f. For each filter bank, filter static-pressure differential in inches wg.

   g. Preheat-coil static-pressure differential in inches wg.

   h. Cooling-coil static-pressure differential in inches wg.

   i. Heating-coil static-pressure differential in inches wg.

   j. List for each internal component with pressure-drop, static-pressure differential in inches wg.

   k. Outdoor airflow in cfm.

   l. Return airflow in cfm.

   m. Outdoor-air damper position.

   n. Return-air damper position.

G. 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. Refrigerant expansion valve and refrigerant types.
   i. Refrigerant suction pressure in psig.
   j. Refrigerant suction temperature in deg F.

H. Gas-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btu/h (kW).
   h. Ignition type.
   i. Burner-control types.
   j. Motor horsepower and speed.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches, and bore.
   n. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.

b. Entering-air temperature in deg F.

c. Leaving-air temperature in deg F.

d. Air temperature differential in deg F.

e. Entering-air static pressure in inches wg.

f. Leaving-air static pressure in inches wg.

g. Air static-pressure differential in inches wg.

h. Low-fire fuel input in Btu/h.

i. High-fire fuel input in Btu/h.

j. Manifold pressure in psig.

k. High-temperature-limit setting in deg F.

l. Operating set point in Btu/h.

m. Motor voltage at each connection.

n. Motor amperage for each phase.

o. Heating value of fuel in Btu/h.

I. 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.

J. 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.

K. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

   a. System fan and air-handling-unit number.

   b. Location and zone.

   c. Traverse air temperature in deg F.

   d. Duct static pressure in inches wg.

   e. Duct size in inches.

   f. Duct area in sq. ft.

   g. Indicated airflow rate in cfm.

   h. Indicated velocity in fpm.

   i. Actual airflow rate in cfm.

   j. Actual average velocity in fpm.

   k. Barometric pressure in psig.

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

   a. Unit identification.

   b. Location.

   c. Service.

   d. Make and size.

   e. Model 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.

M. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.16. INSPECTIONS

A. Initial Inspection:

1. After testing and balancing is complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Perform the inspection in the presence of the owner’s commissioning agent.

3. Check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.

b. Measure water flow of at least 10 percent of terminals.

c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

d. Verify that balancing devices are marked with final balance position.

e. Note deviations from the contract documents in the final report.

B. Final Inspection:

1. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the engineer.

2. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

3. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, owner may contract the services of another TAB contractor to complete TAB work according to the contract documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.17. ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

# SECTION 23 07 13 – DUCT AND DUCTED EQUIPMENT INSULATION

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

### 1.3. QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
2. Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

### 1.4. DELIVERY, STORAGE, AND HANDLING

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

B. Storage: Insulation material shall be stored in a dry location sealed in plastic to prevent moisture infiltration. Insulation material, installed or not, that becomes wet, dirty, etc. shall be removed and replaced. “Dried” or “cleaned” insulation materials shall not be used.

### 1.5. COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

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

### 1.6. SCHEDULING

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

## PART 2 - PRODUCTS

### 2.1. INSULATION MATERIALS

A. General: Comply with requirements in Indoor Duct Insulation and Field-Applied Jacket Schedule and Outdoor Duct Insulation and Field-Applied Jacket Schedule articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, lead, mercury, or mercury compounds.
2. 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.
3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Mineral-Fiber Blanket Insulation: Mineral wool or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290. Provide Type II with factory-applied vinyl jacket; Type III with factory-applied FSK jacket; or Type III with factory-applied FSP jacket.

1. R-value requirements defined in Part 3 of this section as based on installed ratings with 25 percent compression.

C. Mineral-Fiber Board Insulation: Mineral wool 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 jacket.

D. Polyisocyanurate Board Insulation: Closed-cell polyisocyanurate rigid foam boards with aluminum foil facing, ASTM C 1289, Type 1, Grade 1 (-100 to +250F). For outdoor use only.

E. 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.

### 2.2. FACTORY-APPLIED JACKETS

A. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White outward facing, bleached kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing.

2. FSK Jacket: Aluminum-foil outward facing, fiberglass-reinforced scrim with brown kraft-paper backing.

3. PSK Jacket: White outward facing, bleached kraft paper laminated with polypropylene film, fiberglass-reinforced scrim.

2.3. FIELD-APPLIED JACKETS

A. Insulation system schedules indicate field-applied jackets for various applications. When field-applied jackets are indicated, comply with the following:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Moisture Barrier:

      1) Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.

      2) Outdoor Applications: 2.5-mil thick polysurlyn.

2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. Moisture Barrier:

      1) Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.

      2) Outdoor Applications: 2.5-mil thick polysurlyn.

3. PVC Jacket: High-impact resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C, 20-mils thick.

   a. Adhesive: As recommended by jacket material manufacturer.

   b. Color: Comply with Section 230553.

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

2.4. DUCT INSULATION INSTALLATION MATERIALS

A. General: Adhesives, mastics and sealants shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. Indoor applications shall comply with low-VOC requirements of Section 230100.

B. Adhesives:

1. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

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

C. Mastics: Comply with MIL-PRF-19565C, Type II.

1. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

D. Sealants:

1. ASJ Flashing Sealants and Vinyl Flashing Sealants.

2. FSK and Metal Jacket Flashing Sealants.

E. Tapes:

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

3. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

F. Securements:

1. Insulation Pins and Hangers:

a. 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.

b. 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.

c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

d. Non-Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

g. Non-Metal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

3. Wire: 0.062-inch soft-annealed, stainless steel.

G. Corner Angles:

1. 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.

2. Stainless-Steel Corner Angles: 0.024-inch thick, minimum 1 by 1-inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

## PART 3 - EXECUTION

### 3.1. INDOOR DUCT INSULATION AND FIELD-APPLIED JACKET SCHEDULE

A. General

1. Unconditioned spaces include attics, crawl spaces, and unheated mechanical rooms. They do not include vertical shafts surrounded by conditioned spaces.

2. Install field-applied jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. General Duct Systems

1. Concealed single-wall duct in conditioned spaces:

   a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

   b. Return and Relief Air: None.

   c. General Building Exhaust Air: None.

2. Concealed single-wall duct in unconditioned spaces:

   a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

   b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

   c. General Building Exhaust Air: None.

3. Exposed-to-view single-wall duct in mechanical equipment spaces:

a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber board for rectangular duct and mineral fiber blanket for round and flat oval with 0.032-inch thick stucco embossed aluminum field-applied jacket.

b. Return and Relief Air: None.

c. General Building Exhaust Air: None.

4. Exposed-to-view single-wall duct in conditioned spaces:

a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber board for rectangular duct and mineral fiber blanket for round and flat oval with 0.032-inch thick painted smooth aluminum field-applied jacket.

b. Return and Relief Air: None.

c. General Building Exhaust Air: None.

5. Exposed-to-view single-wall duct in unconditioned spaces:

a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket with 0.032-inch thick painted smooth aluminum field-applied jacket.

b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket with 0.032-inch thick painted smooth aluminum field-applied jacket.

c. General Building Exhaust Air: None.

6. Concealed or exposed-to-view double-wall duct interstitial insulation in conditioned spaces:

a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

7. Concealed or exposed-to-view double-wall duct interstitial insulation in unconditioned spaces:

a. Supply and Ventilation Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

b. Return and Relief Air: 2-inches (R-6) of mineral fiber blanket, field-applied jacket is not required.

8. Concealed within chase on an exterior wall or within an exterior wall:

a. Supply and Ventilation Air: 2-inches (R-8) of mineral fiber board, field-applied jacket is not required.

b. Return and Relief Air: 2-inches (R-8) of mineral fiber board, field-applied jacket is not required.

C. Air Plenums

1. Plenums connected to outdoor louvers or hoods:

a. Ventilation Air: 3-inches (R-8) of mineral fiber board with 0.032-inch thick stucco embossed aluminum.

b. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board with 0.032-inch thick stucco embossed aluminum.

2. Plenums not connected directly to the outdoors:

a. Supply Air: 2-inches (R-6) of mineral fiber board with 0.032-inch thick stucco embossed aluminum.

b. Ventilation Air: 3-inches (R-8) of mineral fiber board with 0.032-inch thick stucco embossed aluminum.

c. Exhaust/Relief Air: 2-inches (R-6) of mineral fiber board with 0.032-inch thick stucco embossed aluminum.

3. Acoustic Plenums and Duct Silencers: Interior or interstitial duct liner shall have the same or greater thermal resistance as the systems they are attached as indicated above.

3.2. OUTDOOR DUCT INSULATION AND FIELD-APPLIED JACKET SCHEDULE

A. General Requirements:

1. Outdoor Duct: Install jacket with a single Z-shaped locking longitudinal seam on the underside of the raised duct and with Z-shaped locking seam traverse joints. All seams shall be mechanically fastened and watertight sealed with flexible mastic.

B. General Duct Systems

1. Single-wall duct:

a. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate with 45-mil thermoplastic polyolefin (TPO) single-ply white roof membrane with aluminum corner angles.

b. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate with 0.032-inch thick stucco embossed aluminum.

c. Exhaust/Relief Air: None.

2. Double-wall duct interstitial insulation:

a. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate, field-applied jacket is not required.

b. Exhaust/Relief Air: None.

C. Plenums

1. Plenums shall be insulated as follows:

a. Supply, Ventilation and Return Air: 2-inches (R-10) of polyisocyanurate with 0.032-inch thick stucco embossed aluminum.

b. Exhaust/Relief Air: None.

2. Acoustic Plenums and Duct Silencers: Interior or interstitial duct liner shall have the same or greater thermal resistance as the systems they are attached as indicated above.

3.3. GENERAL REQUIREMENTS

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.

3.4. PREPARATION

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

3.5. GENERAL INSTALLATION REQUIREMENTS

A. Insulate all components of duct systems as specified with the exception of the following components:

1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

B. Provide rigid board insulation strips at duct supports to avoid compression of duct wrap.

C. For ductwork conveying air below ambient temperature, insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, expansion joints, and the backs of supply diffusers.

D. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

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

F. 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.

G. Install insulation with longitudinal seams at top and bottom of horizontal runs.

H. Install multiple layers of insulation with longitudinal and end seams staggered.

I. Keep insulation materials dry during application and finishing.

J. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

K. Install insulation with least number of joints practical.

L. 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.

M. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

N. 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.
4. For below ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

O. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

Q. 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.

3.6. 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 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: 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.

E. 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.

3.7. INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap un-faced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

   d. Do not over-compress insulation during installation.

   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

## 3.8. INSTALLATION OF POLYISOCYANURATE 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 per unit area.

   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

    d. Do not over-compress insulation during installation.

    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

## 3.9. FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12-inches o.c. and at end joints.

3.10. 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 230500.

3.11. FINISHES

A. Paint duct insulation with ASJ, glass-cloth, or other paintable jacket material. Color shall be selected by the Owner/Engineer. Refer to Section 230553.

1. Prime with 2 coats of water-based white acrylic primer paint designed for use with associated jacket material.
2. Finish with 2 coats of flat latex paint with fungicidal agent additive to render fabric mildew proof.
3. Do not field paint stainless-steel jackets.

B. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

C. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55 deg F; not more than 90 deg F; and not more than 70 percent RH.

D. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

END OF SECTION

# SECTION 23 31 13 – METAL DUCTS

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. PERFORMANCE REQUIREMENTS

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

B. Delegated Outdoor Duct Support Design: Duct support construction shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and be suitable for outdoor conditions including attachment details and support and curb heights for snow and rain.

1. Comply with Section 230548 for wind and seismic restraints.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE-62.1.

### 1.3. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. Shop Drawings: For all new ductwork and accessories.

a. Factory and shop-fabricated ducts and fittings.

b. Reinforcement and spacing.

c. Seam and joint construction.

d. Details for penetrations through fire-rated and other partitions.

e. Hangers and supports, including methods for duct and building attachment and vibration isolation.

f. Sheet metal thicknesses.

2. 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:

a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

b. Suspended ceiling components.

c. Structural members to which duct will be attached.

d. Size and location of initial access modules for acoustical tile.

e. Penetrations of smoke barriers and fire-rated construction.

f. Items penetrating finished ceiling

B. Construction Submittals:

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

C. Close-Out Submittals:

1. As-Built Documents: Provide revised coordination drawings to match the installed conditions.

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

1.4. DEFINITIONS

A. System Operating Pressure: Duct system operating pressure is equal to the scheduled external static pressure, unless otherwise noted.

1. Duct downstream of air terminal units, between terminal unit discharge and diffuser inlet, the operating pressure may be reduced to 1-inch w.g., unless otherwise noted.

PART 2 - PRODUCTS

2.1. 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 Steel Sheets: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation:

a. G60: Non-hazardous systems such as supply, return, ventilation, relief and general building exhaust duct installed indoors.

b. G90: Hazardous exhaust duct and all duct installed outdoors.

2. Finishes for Surfaces Exposed-to-View: Mill phosphatized.

3. Finishes for Surfaces Exposed-to-View: Painted.

C. PVC-Coated Galvanized Steel Sheets: Comply with ASTM A 653/A 653M.

1. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.

2. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316 or 304, cold rolled, annealed, sheet. Exposed surface finish shall be No.4.

E. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

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.

H. 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: White

6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

7. Manufacturer: Fosters 40-20 fungicidal protective coating.

## 2.2. DUCT CONSTRUCTION

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class with the following exceptions:

1. Minimum Sheet Metal Thickness:

    a. Non-hazardous ducted systems including supply, return, ventilation, relief and general building exhaust air.

        1) Galvanized Sheet Steel: 0.028-inches (24-gage).

        2) Stainless Sheet Steel: 0.025-inches (24-gage).

        3) Aluminum Sheet Metal: 0.020-inches (24-gage).

    b. Hazardous ducted systems including laboratory fume hood exhaust, healthcare and laboratory specialty exhaust and vehicle fume exhaust air.

        1) Galvanized and Stainless Sheet Steel: 24-gage for up to 8-inch duct diameter or largest dimension; 22-gage for up to 18-inch duct; 20-gage for up to 30-inch duct; and 18-gage for greater than 30-inch duct.

2. Minimum Construction Standards: Refer to the Table below for minimum construction standards in addition to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

METAL DUCT MINIMUM CONSTRUCTION STANDARDS

| DUCT SYSTEMS | MAXIMUM OPERATING PRESSURE (+/- IN WG) | SMACNA DUCT PRESSURE CLASS. (+/- IN WG) | SMACNA SEAL CLASS (A, B or C) | SMACNA LEAKAGE CLASS (CL) | LONGITUDINAL SEAM TYPES | TRANSVERSE JOINT TYPES | FITTING CONSTRUCTION |
|---|---|---|---|---|---|---|---|
| RECTANGULAR DUCT | 1.0 | 1 | B | 8 | L-1 | T-1, 3, 6, 17, 19, 22, 24 (Note #3) | 6, 7 and 8 |
| | 1.5 | 2 | B | 8 | L-1 | T-1, 3, 6, 17, 19, 22, 24 (Note #3) | 6 and 7 |
| | 2.5 | 3 | A | 8 | L-1 | T-17, 19, 22 and 24 (Note #3) | 6 and 7 |
| | 3.0 | 4 | A | 4 | L-1 | T-22 (Note #3) | 6 and 7 |
| | 5.0 | 6 | A | 4 | L-1 | T-22 (Note #3) | 6 and 7 |
| | 8.0 | 10 | A | 4 | L-1 | T-22 (Note #3) | 6 and 7 |
| ROUND DUCT WITH LONGITUDINAL SEAMS | 1.0 | 1 | B | 8 | RL-4, 5, 6A, 6B, 7 and 8 | RT-1, 2, 3, 4, 5 and 6 (Note #4) | 10 and 14 |
| | 1.5 | 2 | B | 8 | RL-4 and 5 | RT-1 and 2 (Note #4) | 10, 11, 13 and 14 |
| | 2.5 | 3 | A | 4 | RL-4 and 5 | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 3.0 | 4 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 5.0 | 6 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 8.0 | 10 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| ROUND DUCT WITH SPIRAL SEAMS | 1.0 | 1 | B | 8 | RL-1 (Spiral) | RT-1 and 2 (Note #4) | 10, 11, 13 and 14 |
| | 1.5 | 2 | B | 8 | RL-1 (Spiral) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 2.5 | 3 | A | 4 | RL-1 (Spiral) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 3.0 | 4 | A | 2 | RL-1 (Spiral) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 5.0 | 6 | A | 2 | RL-1 (Spiral) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| | 8.0 | 10 | A | 2 | RL-1 (Spiral) | RT-2 (Note #4) | 10, 11, 13 and 14 |
| FLAT OVAL DUCT WITH LONGITUDINAL SEAMS | 1.0 | 1 | B | 8 | RL-4 and 5 | RT-2 (Note #5) | 12, 13 and 14 |
| | 1.5 | 2 | B | 8 | RL-4 and 5 | RT-2 (Note #5) | 12, 13 and 14 |
| | 2.5 | 3 | A | 4 | RL-4 and 5 | RT-2 (Note #5) | 12, 13 and 14 |
| | 3.0 | 4 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #5) | 12, 13 and 14 |
| | 5.0 | 6 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #5) | 12, 13 and 14 |
| | 8.0 | 10 | A | 2 | RL-4 and 5 (Poss. Press. Only) | RT-2 (Note #5) | 12, 13 and 14 |
| FLAT OVAL DUCT WITH SPIRAL SEAMS | 1.0 | 1 | B | 8 | RL-1 (Spiral) | RT-1 and 2 (Note #5) | 12, 13 and 14 |
| | 1.5 | 2 | B | 8 | RL-1 (Spiral) | RT-2 (Note #5) | 12, 13 and 14 |
| | 2.5 | 3 | A | 4 | RL-1 (Spiral) | RT-2 (Note #5) | 12, 13 and 14 |
| | 3.0 | 4 | A | 2 | RL-1 (Spiral) | RT-2 (Note #5) | 12, 13 and 14 |
| | 5.0 | 6 | A | 2 | RL-1 (Spiral) | RT-2 (Note #5) | 12, 13 and 14 |
| | 8.0 | 10 | A | 2 | RL-1 (Spiral) | RT-2 (Note #5) | 12, 13 and 14 |

NOTES:

1. REFER TO SMACNA 'HVAC DUCT CONSTRUCTION STANDARD - METAL AND FLEXIBLE' (2005) FOR SEAM, JOINT AND FITTING TYPES.
2. REFER TO SMACNA 'HVAC AIR DUCT LEAKAGE TEST MANUAL' (2012) FOR PRESSURE, SEAL AND LEAKAGE CLASSES.
3. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE TYPE 35 OR 25, OR EQUAL BY WARD OR NEXUS.
4. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE SPIRAL-MATE, OR EQUAL BY WARD OR NEXUS.
5. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE OVAL-MATE, OR EQUAL BY WARD OR NEXUS.
6. OPERATING PRESSURES ARE BASED ON MAXIMUM DESIGN PRESSURES, ALSO REPRESENTED AS EXTERNAL STATIC PRESSURES (ESP).
7. USE MINIMUM SMACNA DUCT PRESSURE CLASSIFICATION OF 1 IN WG. DO NOT USE 1/2 INCH CLASSIFICATION.

B. Double-Wall Duct:

1. Double-wall rectangular ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.

    a. Interstitial Insulation: Comply with Section 230713.

    b. Minimum Thermal Resistance: Comply with Section 230713.

c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

d. Coat insulation with antimicrobial coating.

e. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

2. Double-wall round and flat-oval ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.

a. Interstitial Insulation: Comply with Section 230713

b. Minimum Thermal Resistance: Comply with Section 230713

c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

d. Coat insulation with antimicrobial coating.

e. Inner Duct: Minimum 24-gage solid galvanized sheet steel.

C. Intermediate Reinforcement: Match duct material.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE-1 with minimum 1.5 radius-to-diameter ratio.

b. Radius Type RE-3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE-2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

1) Fabricate elbows with single thickness blades with 2-inch inside radius for ducts with dimensions up to 18x18 and double thickness blades for dimensions 18x18 and larger.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Elbows shall be solid welded gored type constructed in accordance with Fig. 3-6 and Table 3-1 of SMACNA HVAC Duct Construction Standards. Mitered elbows may only be used where indicated on the Drawings. When used, mitered elbows shall always be supplied with single thickness turning vanes.

b. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible”.

1) Velocity up to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

2) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

c. Round Elbows:

1) Diameter 8-inches and Smaller: Stamped or pleated.

a) Adjustable elbows with lock-form joints are also acceptable.

2) Diameter 10-inches and Larger: Welded gore-type.

a) 90-degree elbows shall have minimum 5 gores.

b) 45-degree elbows shall have minimum 3 gores.

E. 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:

1) Velocity up to 1500 fpm: Conical.

2) Velocity greater than 1500 fpm: 45-degree lateral.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Round and Flat Oval Main to Round Branch:

1) Velocity up to 1000 fpm: 90-degree tee.

2) Velocity up to 2000 fpm: Conical.

3) Velocity greater than 2000 fpm: 45-degree lateral.

3. Construct tees, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.

4. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

5. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4-inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

6. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections. Straight 90-degree round take-offs are allowed off rectangular ducts for single diffuser taps only.

7. Divided or diverging flow fittings shall be constructed as separate fittings. Tap collars welded into spiral duct sections are not acceptable.

F. Exhaust Hood Connections: Gasketed flanges compatible with hood usage.

G. General Cleanliness Requirements: Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines".

1. Minimum Duct Cleanliness Level: C ("Advanced Level")

a. Internal surfaces shall be wiped clean after fabrication prior to sealing for shipment.

b. Self-adhesive labels may be affixed to only the outside surfaces of the duct.

2.3. TRAVERSE DUCT CONNECTION SYSTEM

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

1. Ductmate.

2. Ward.

3. Nexus.

B. Product Description: SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

C. Duct connectors shall be equal to Ductmate 35 or 25 Systems, slide-on type. The 35 System joint shall be the equivalent of a SMACNA "J" connection. The 25 System joint shall be the equivalent of the SMACNA "F" connection. Duct connectors shall be tested by an independent recognized testing laboratory.

D. Duct connectors shall consist of roll formed angle frames with integral sealant, corner pieces with nuts and bolts, metal cleats and gasketing. (Metal cleats only, PVC cleats not acceptable, with the exception of breakaway joints at fire damper sleeves.)

E. Gasketing shall be equal to Ductmate Type 440 synthetic polymer (Butyl) based gasket/sealing tape or approved equal.

F. Connectors shall be selected for the system duct construction specified. Select in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible and the manufacturers published criteria for positive and negative applications. The manufacturer shall assist in the selection of all duct connectors. Select methods of construction and gages as required to accommodate prefabricated duct connectors.

G. Angle flange connectors shall be fastened in each corner and 12-inches o/c minimum thereafter unless the MFR requires more stringent fastening. The type/style of fastening must be submitted for approval prior to ductwork fabrication.

2.4. PRE-FABRICATED GREASE DUCTS

A. Description: Zero-clearance double-wall metal vents tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

B. Construction: ASTM A 666, Type 304 stainless steel inner shell and stainless steel outer jacket with No. 4 finish when exposed-to-view, separated by at least 2-inch annular space filled with high-temperature, ceramic-fiber insulation.

C. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

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. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 4 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.

a. Type: S.

b. Grade: NS.

c. Class: 25.

d. Use: O.

2. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

2.6. 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. DUCT SCHEDULE

A. General Building Air Systems: Applies to general building supply, return, exhaust, ventilation and relief air duct. Refer to Part 2, Metal Duct Minimum Construction Standards chart for construction standards of standard supply, transfer, return and exhaust duct. Refer to this Duct Schedule section for special applications.

1. Indoor Duct:

   a. Concealed or Exposed to View in Mechanical Rooms: Single-wall galvanized sheet steel. Round and oval duct shall have longitudinal or spiral seams.

   b. Exposed to View in Occupied Spaces: Double-wall galvanized sheet steel. Round and oval duct shall have spiral seams.

2. Outdoor Duct:

   a. Insulated Systems: Double-wall galvanized steel with painted flat white exterior surfaces.

   b. Insulated Systems: Double-wall Type 304 stainless steel outer shell and galvanized steel inner duct.

   c. Insulated Systems: Single-wall galvanized steel. Refer to Section 230713 for insulation and field-applied jacket requirements.

   d. Insulated Systems: Single-wall Type 304 stainless steel. Refer to Section 230713 for insulation and field-applied jacket requirements.

   e. Uninsulated Systems: Single-wall galvanized steel.

   f. Uninsulated Systems: Single-wall Type 304 stainless steel.

B. Air Plenums: Applies to air plenums for general building ventilation and relief air systems.

1. Construction: Plenums shall be constructed with materials matching connected duct construction.

2. Access Doors: Refer to Section 233300 for access door requirements.

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. Duct Dimensions: Dimensions in the construction documents indicate as follows:

1. Rectangular Duct: Nominal inside width and height of the duct.

2. Round Duct: Nominal inside diameter of the duct.
3. Oval Duct: Nominal inside width and depth diameter (of the round sides connecting the flat portions) of the duct.
4. Double-Wall Duct: For double-wall duct, the inside is defined as the inner-duct.

C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Install ducts according to SMACNA's "Duct Cleanliness for New Construction Guidelines".

1. Store duct, fittings and accessories on pallets in a clean and dry location.
2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place.
3. Temporary filter media shall be installed on both return and exhaust ducts/inlets if system is operated for conditioning prior to occupancy.
4. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating.

E. Install round and flat-oval ducts in maximum practical lengths.

F. Install ducts with fewest possible joints.

G. Install factory or shop fabricated fittings for changes in direction, size, and shape and for branch connections.

H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1-inch plus allowance for insulation thickness.

K. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

L. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

M. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements of the specifications for fire and smoke dampers.

N. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.3. DUCT WELDING

A. Duct welding materials and methods shall be in accordance with AWS Standard D9.1-90 Sheet Metal Welding Code.

B. Electrode material and flux shall be compatible with the sheet metal material being welded.

C. Re-coat any galvanizing damaged as a result of welding with a zinc-rich paint, such as Porter Zinc-Lock 351 – Gray.

D. Stainless Steel Ductwork Welding:

1. Welding Process: Welding process shall be inert gas shielded tungsten arc process. Electric current for welding shall be direct current, straight polarity (electrode negative and work positive).
2. Shielding and Purging: Shielding and purging gas shall be welding grade helium, argon or a mixture of both.
3. Electrodes: Electrodes shall be 2-percent thoriated tungsten conforming to AWS classification and complying with AWS A5.4, AWS A5.9, and AWS A5.12.
4. Grinding and Polishing: The inside and outside of welds shall have burrs and rough spots removed with a tungsten carbide file or grinder. Final polishing shall be with the proper grit (free of iron) abrasive grinder with flexible flap, drum or roll wheel.

3.4. 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.

3.5. 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.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 10 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Install outdoor duct, supports and building attachments to comply with Section 230548 wind and seismic restraint requirements. Coordinate attachments with building structure and roof.

3.6. CONNECTIONS

A. Make connections to equipment with flexible connectors.

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

3.7. PAINTING

A. Paint interior of all metal duct that is visible through registers and grilles and that does not have duct liner.

B. Paint exterior of all galvanized metal duct that is exposed-to-view. Do not paint stainless steel duct unless otherwise directed.

1. Exception: Do not paint duct in mechanical rooms, mezzanines or penthouses.

C. Painting Duct:

1. Clean duct of dirt, grease and lubricants with a non-hydrocarbon “green” cleaner.

2. Prime duct with 2 coats of water-based white acrylic primer paint designed for use with galvanized steel.

3. Finish duct with 2 coats of latex paint.

a. Exterior Duct Surfaces: Color and finish shall be chosen by the owner/ architect.

b. Interior Duct Surfaces: Flat black.

D. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.

E. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.

F. Mill phosphatized or bonderized ”paint grip” steel is not acceptable. Galvannealed sheet metal using a continuous hot-dipping method is an acceptable alternative.

3.8. FIELD QUALITY CONTROL

A. Engineer to inspect all ductwork at operating pressure prior to insulation for leakage. All leakage shall be repaired.

B. Perform tests and inspections.

C. Leakage Pressure Tests:

1. Test 100% of supply, return, exhaust, relief and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.

   a. Low pressure duct (2-inches w.g. or less) listed below shall be tested for leakage unless, in the judgement of the Engineer, it is not required. The Engineer has the option to make this judgement based on a visual inspection of the quality of sealant application. Poor workmanship will result in leakage testing of all duct.

      1) Return air duct for return plenum systems under negative pressure and less than 30 ft. total length of duct.

      2) Return air duct from the intake of fan coil units and blower coil units under negative pressure and less than 30 ft. total length of duct.

      3) Exhaust air duct under negative pressure and less than 30 ft total length of duct.

      4) Ventilation air duct under negative pressure and less than 30 ft. total length of duct.

      5) Supply air duct from the discharge of terminal units, fan coil units and blower coil units under positive pressure and less than 30 ft. total length of duct.

2. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter 19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Test for leaks before applying external insulation.

5. Provide 10-day notice for testing.

6. Testing performed prior to the installation of duct accessories, such as dampers and access doors, is not valid. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.

D. Leakage Light Tests:

1. Test 100% of commercial kitchen hood exhaust air duct. Perform leakage test using light complying with the current edition of the Mechanical Code and the following, whichever is stricter.
    a. Perform the tests in low ambient light levels.
    b. Pass a 2500 lumen light source, such as a 150-watt incandescent or 40 watt LED lamp, through the entire length of the duct.
    c. Inspect 100% of all joints to ensure they are liquid-tight.
    d. If light is detected at any point, remake and retest joints until all pass.
    e. Once the duct is completely tested and proved compliant, allow the Owner and Engineer to witness the test.

E. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

F. Duct system will be considered defective if it does not pass tests and inspections.

G. 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 specification 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.

END OF SECTION

# SECTION 23 33 00 – METAL DUCT ACCESSORIES

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Close-Out Submittals:

C. Life-Safety Damper Inspection Reports: Document testing and results for all life-safety dampers including installation and operation inspection, engineer’s inspections and AHJ’s inspections.

1. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

### 1.3. EXTRA MATERIALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed but no less than 10 total.

## PART 2 - PRODUCTS

### 2.1. ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Provide dampers constructed with materials matching the duct system.

1. Exception: Use Type 304 stainless steel in galvanized duct subject to moist airstreams such as humidifiers, locker room exhaust, pool rooms, steam autoclaves, etc.

## 2.2. MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.

2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

## 2.3. STATIC PRESSURE GAGES

A. Dial Gages: 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2-percent of full scale accuracy.

B. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4-inch diameter tubing. Provide 3-way vent valves.

## 2.4. GRAVITY BALANCED BACKDRAFT DAMPERS

A. Description: Gravity-balanced dampers for backdraft. Dampers shall have adjustable tension return spring; steel ball bearings; counter-weights and spring-assist kits for vertical flow applications; and bird screens. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2-inches w.g. maximum system pressure.

1. Frame: Hat-shaped with welded corners or mechanically attached and mounting flange, constructed of one of the following to match the duct system material type for each: 12-gauge thick, galvanized sheet steel; 0.063-inch thick extruded aluminum; or 0.05-inch thick stainless steel.

2. Blades: Parallel-action, multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch thick, roll-formed aluminum with mechanically-locked neoprene blade seals and 0.20-inch diameter stainless steel blade axles.

2.5. BAROMETRIC RELIEF DAMPERS

A. Description: Barometric relief dampers for pressure relief. Dampers shall have adjustable tensions return spring or adjustable counter-weight; stainless steel bearings; and bird screens. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2-inches w.g. maximum system pressure. Ruskin CBD4, Greenheck BR-30, Pottorff CBD-150.

1. Frame: Hat-shaped with welded corners or mechanically attached and mounting flange, constructed of one of the following to match the duct system material type for each: 16-gauge thick, galvanized sheet steel; 0.093-inch thick extruded aluminum; or 18-gauge stainless steel.

2. Blades: Parallel-action, multiple single-piece blades, center pivoted, maximum 6-inch width, 0.050-inch thick, roll-formed aluminum with mechanically-locked neoprene blade seals and 0.20-inch diameter stainless steel blade axles.

2.6. MANUAL VOLUME DAMPERS

A. Standard Rectangular, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 2000 fpm maximum air velocity and 2.5-inches w.g. maximum system pressure. Ruskin MD35, Greenheck MBD-15, Pottorff MD-42.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.

2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 8-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.

B. Standard Round, Steel, Manual Volume Dampers: Standard leakage rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 1500 fpm maximum air velocity and 2-inches w.g. maximum system pressure. Ruskin MDRS25, Greenheck MBDR-50, Pottorff CD-10R.

1. Frame: Constructed of 20-gauge thick galvanized sheet steel, flangeless for in duct installations.

2. Blades: Single-blade, center-pivot, 20-gauge thick galvanized sheet steel, 0.375-inch diameter galvanized steel blade axle and 90-deg quadrant handle. Provide 2-inch handle extension wherever duct system will be insulated.

C. Damper Hardware: Zinc-plated, die-cast core with hand quadrant dial and handle made of 3/32-inch thick zinc-plated steel, and hexagon locking nut. Include elevated platform for insulated duct mounting.

1. Handle operation shall be painted orange.

2.7. CONTROL DAMPERS

A. Standard Low-Pressure Rectangular, Steel, Control Dampers: Standard leakage rated damper suitable for horizontal or vertical volume control applications with synthetic or stainless steel bearings. Dampers shall be rated for 2,000 fpm maximum air velocity, 2.5-inches w.g. maximum system pressure and maximum leakage of 10 cfm/sqft. at 1.0-inches pressure. Ruskin CD35, Greenheck VCD-23, Pottorff CD-42.

1. Frame: Hat-shaped with welded corners, constructed of 16-gauge thick, galvanized sheet steel, with flanges for wall attachments or flangeless for in duct installations.

2. Blades: Opposed-blade action, multiple single-piece blades, center-pivot, maximum 6-inch width, 16-gauge thick galvanized steel, galvanized steel blade axles and exposed linkage. Provide 2-inch handle extension wherever duct system will be insulated.

3. Applications:

   a. Operating Pressure: Up to 2.0-inches w.g.

   b. Operating velocity: Up to 1,500 fpm.

   c. Throttling: Opposed-blade type.

   d. Two-Position (Open/Closed): Parallel type.

B. Standard Low-Pressure Round, Steel, Control Dampers: Standard rating suitable for horizontal or vertical volume control applications with molded synthetic bearings. Unless otherwise indicated, dampers shall be rated for 1,500 fpm maximum air velocity and 2.0-inches w.g. maximum system pressure. Provide dampers equivalent to Ruskin MDRS25, Greenheck VCDR-53, Pottorff CD-25R.

1. Frame: Constructed of 20-gauge thick galvanized sheet steel, either with flanges on both sides or internal duct mounting.

2. Blades: Single-blade action, 20 gauge-thick steel, center-pivot, closed cell rubber edge seals and galvanized steel blade axles.

3. Applications:

   a. Operating Pressure: Up to 1.0-inches w.g.

   b. Operating velocity: Up to 1,000 fpm.

2.8. DUCT SILENCERS

A. Test according to ASTM E-477.

B. Rectangular Dissipative Silencer: Factory-fabricated, rectangular straight with splitters or baffles, dissipative silencer. Outer casing, inner casing and baffles shall be constructed of minimum 20-gauge thick G60 galvanized sheet steel. Inner casing and baffles shall be perforated. Sound absorbing fill material shall have an erosion barrier lining. All materials, adhesives and sealants shall have a flame-spread index of 25 or less and a smoke-developed index of 50 or less in accordance with ASTM E-84.

C. Rectangular Reactive Silencer: Factory-fabricated, rectangular straight with pods, reactive silencer. Outer casing, inner casing and pods shall be constructed of minimum 20-gauge thick G60 galvanized sheet steel. Sound absorbing tuned resonator cavities shall be made completely of steel; non-metal materials may not be used.

D. Elbow Silencer for Fan-Powered Terminal Intakes: Factory-fabricated, rectangular elbow with splitters or baffles, dissipative silencer. Outer casing, inner casing and baffles shall be constructed of minimum 20-gauge thick G60 galvanized sheet steel. Inner casing and baffles shall be perforated. Sound absorbing fill material shall have an erosion barrier lining. All materials, adhesives and sealants shall have a flame-spread index of 25 or less and a smoke-developed index of 50 or less in accordance with ASTM E-84.

E. Refer to drawings for performance parameters including dynamic insertion losses at 8 octave bands, pressure drop and length.

F. Factory-installed end caps to prevent contamination during shipping.

2.9. TURNING VANES

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

2.10. REMOTE DAMPER OPERATORS

A. Manual Cable Type Remote Damper Actuator: Cable system designed for remote manual damper adjustment. Cable system shall consist of steel cable within aluminum tubing at lengths required from damper actuator to access point. External cable system shall have recessed galvanized steel back-box at wall or ceiling termination with stainless steel faceplate for removable wrench or screwdriver actuation. Internal cable system shall terminate behind the diffuser or grille face and be accessible through its face.

B. Provide die cast ceiling cup with cover plate at hard gypsum board ceilings. Cover plate shall match ceiling color selected by architect. For slat type ceiling systems with an interstitial gap, provide controller mounted above the slat ceiling with attachment to the slat ceiling system. Removable wrench or screwdriver actuation shall access the operator through the interstitial gap. Provide multi-port balancing station for multiple dampers.

2.11. DUCT-MOUNTED ACCESS DOORS

A. General: Factory-fabricated access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Doors: Factory-fabricated access doors shall be air-tight suitable for associated duct pressure and leakage classification. All doors shall be rigid and close fitting and include sealing gaskets and quick locking devices. Door construction materials shall match metal duct type, galvanized steel, stainless steel or aluminum.

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

    b. Access panels with sheet metal screw fasteners are not acceptable.

2. Frames: Galvanized sheet steel, with bend-over tabs and foam or neoprene gaskets. Security chain to restrain door to frame.

3. Hinges and Latches:

   a. Doors up to 12-inches Square: Secure with sash locks.

   b. Doors up to 18-inches Square: Provide two hinges and two sash locks.

   c. Doors up to 24 x 48 Inches: Three hinges and two compression latches with outside and inside handles.

   d. Larger door sizes: Provide an additional hinge.

4. Vision Panels: 12-inch square wired-glass vision panels in all access doors larger than 6 sqft. and where noted, including:

   a. Plenum Access Doors.

   b. Humidifiers.

B. Standard Duct-Mounted Access Doors: Doors in uninsulated duct shall be single-wall. Doors in insulated duct shall be double-wall with 1-inch of mineral fiber or foam insulation fill.

1. Rectangular Duct-Mounted Access Doors: Rectangular and square access doors for rectangular and flat oval duct.

   a. Life-Safety Damper Access: Doors installed to provide access to life-safety dampers shall be minimum 12-inches square.

      1) Duct without a 14-inch or larger dimension shall transition to a size with at least one 14-inch dimension to allow for 12-inch square access door.

         a) Exemptions: Sidewall grilles and ceiling radiation dampers.

      2) Ducts with a dimension from 14 to 24-inches shall have square access doors 2-inches less than largest duct dimension.

      3) Ducts with a dimension of 26-inches or larger shall have 24-inch by 24-inch duct access doors.

   b. Equipment and Sensor Access: 12 x 6-inch rectangular access doors shall be used in 8-inch largest dimension ducts; 12 x 8-inch rectangular doors in up to 12-inch ducts; 12-inch square doors in up to 18-inch ducts; 18-inch square doors in up to 24-inch ducts; and 24-inch square doors in 26-inch and larger ducts.

2. Oval and Round Duct-Mounted Access Doors: Oval access doors for round and oval ducts. Equivalent to Ruskin ADR Series.

   a. Door Sizes: 8-inch by 4-inch access doors shall be used in 4 and 6-inch diameter round ducts; 10-inch by 6-inch doors in 6 to 12-inch ducts; and 16-inch by 12-inch doors in 14-inch and larger ducts.

1) Life-Safety Damper Access: Transition round and oval duct to rectangular duct matching life-safety damper dimensions. Install access doors in accordance with Rectangular Duct-Mounted Access Doors paragraph above.

C. Plenum-Mounted Access Doors: Open outward for positive-pressure ducts and inward for negative-pressure ducts. Full height plenums shall have 72-inch tall x 30-inch wide door with vision panel and mounted between 4 and 12-inches above the floor unless otherwise indicated.

2.12. DUCT TEST HOLES

A. Permanent Test Holes: Factory-fabricated, air-tight, flanged fittings with screw cap. Furnish extended neck fittings to clear insulation.

2.13. FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene with a minimum weight of 26 oz/sqyd; tensile strength of 480 lbf/inch in the wrap and 360 lbf/inch in the filling; and a service temperature range of (-) 40 deg F to 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone with a minimum weight of 24 oz/sqyd; tensile strength of 530 lbf/inch in the wrap and 440 lbf/inch in the filling; and a service temperature range of (-) 50 deg F to 250 deg F.

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber with a minimum weight of 16 oz/sqyd; tensile strength of 285 lbf/inch in the wrap and 185 lbf/inch in the filling; and a service temperature range of (-) 65 deg F to 500 deg F.

G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating with a minimum weight of 14 oz/sqyd; tensile strength of 450 lbf/inch in the wrap and 340 lbf/inch in the filling; and a service temperature range of (-) 65 deg F to 500 deg F.

H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct. They shall be factory-fabricated for HVAC applications up to 10-inches w.g. of pressure.

I. Grounding Straps: Flexible braided copper grounding strips, flat or round, providing an equivalent ampacity of a #6 AWG conductor.

2.14. FLEXIBLE DUCTS

A. General: Flexible duct shall comply with UL 181, Class 1 and have flame spread rating of less than 25 and smoke developed rating of less than 50.

B. Non-Insulated, Flexible Duct: Aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 20 deg F to 210 deg F.

C. Insulated, Flexible Duct: Double-ply polyester film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film. Duct shall have 10-inch w.g. positive and 1-inch w.g. negative pressure ratings; maximum air velocity of 4000 fpm; and temperature rating of (-) 10 deg F to 160 deg F. Insulation value shall meet or exceed R-value of connected duct insulation.

D. Flexible Duct Connectors: Stainless steel bands with cadium-plated hex screws to tighten band with a worm gear action sized to suit duct size.

## 2.15. DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

# PART 3 - EXECUTION

## 3.1. INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install static pressure gages to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gage.

   1. Provide instruments with scale ranges selected according to service with largest appropriate scale. Filter gauges shall be 0 to 2-inch scale.

D. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

E. Whether or not indicated on plans, install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel. Damper construction materials shall match duct system materials.

1. Volume damper handle positions shall match volume damper positions. If the damper is closed, the handle should be perpendicular to the direction of airflow. If the damper is open, the handle should be parallel to the direction of airflow.

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.

H. Install life-safety dampers according to UL listing and coordinate their location and adjacent installations to ensure they are fully accessible for maintenance and testing.

I. Install smoke and combination smoke and fire damper test panels above ceiling and on walls adjacent to dampers. Coordinate exact locations with Engineer and Owner.

J. Install duct security bars where indicated. Connect duct security bars to ducts with flexible connections. Provide 12-inch by 12-inch hinged access panel with cam lock in duct in each side of sleeve.

K. Connect ducts to duct silencers rigidly unless otherwise indicated.

L. Access Doors: Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. Upstream or downstream from duct silencers.
8. Control devices requiring inspection or cleaning.
9. Elsewhere as indicated.

M. Install access doors with swing against duct static pressure.

N. Label access doors according to Section 230553 to indicate the purpose of access door.

O. Install pressure relief doors in manufacturer recommend orientation, generally vertical, and in locations within mechanical space and opening away from maintenance walkways. Paint doors safety orange.

P. Install temporary duct test holes as required for testing and balancing purposes. Cut or drill ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

Q. Install flexible connectors to connect ducts to equipment. Install flexible grounding strip(s) from equipment to duct.

R. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

S. Connect diffusers to ducts with <u>up to 6-foot maximum lengths of flexible duct</u> clamped or strapped in place, unless otherwise indicated.

T. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws and tape.

U. Install duct test holes where required for testing and balancing purposes.

V. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2. CONTROL DAMPERS

A. Control Dampers for Air Handling Equipment:

1. Outside Air (OA) Dampers: Provide damper types noted in the air handling unit sections and on the drawings. Dampers sized for 2,000 FPM face velocity at full flow and 100 FPM at 5-percent flow.

    a. Opposed-blade type.

    b. Parallel-blade type. Orient blades to direct air flow away from coils and toward outside air flow to promote mixing.

2. Relief Air (RelA) / Exhaust Air (EA) Dampers:

    a. Fan: Opposed-blade type sized for 2,000 FPM face velocity at full flow.

    b. Barometric: Parallel-blade type sized for 1,000 FPM face velocity at full flow.

3. Return Air (RA) Dampers: Parallel-blade type sized for 1,500 FPM face velocity at full flow. Orient blades to direct air flow away from coils and toward outside air flow to promote mixing.

4. AHU RA Inlet / SA Outlet: Smoke isolation dampers, full duct or opening size.

3.3. FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.

4. Inspect turning vanes for proper and secure installation.

5. Operate remote damper operators to verify full range of movement of operator and damper.

6. Life-Safety Damper Testing: Dampers shall be 100% tested and verified to be open and operational through their full range of movement. Damper testing shall be performed by contractor with minimum 5-years of experience in testing life-safety dampers. Within 2 weeks of written certification that all dampers are correct, Engineer shall inspect dampers prior to AHJ inspection.

    a. Test Procedures:

        1) Fire dampers with fusible links shall be tested by removing the fusible link. Observe that damper closes completely.

        2) Fire dampers with firestats shall be tested with a heat gun. Observe that damper closes completely.

        3) Smoke dampers shall be tested by smoking the duct smoke detector with canned smoke. Observe that damper closes completely. In cases where smoke dampers are controlled through the Fire Alarm Control Panel and do not necessarily close on individual duct smoke detectors, use the FACP to close the dampers.

        4) If any dampers do not close completely, correct installation and retest.

        5) After verification of damper closing, verify that damper reopens to normal position without blockage of air flow. Reset fusible links and firestats. Close access door.

    b. Test Report:

        1) Provide written report to Engineer and signed by the responsible Contractor representatives.

        2) Report shall list each fire and smoke damper with test results for each damper including time, date, and name of test technician for each test.

        3) Report shall include a table showing each damper with a unique identification for each damper. Report shall include a notation of whether damper is in supply, return, exhaust or other type of duct.

        4) Report shall include drawings showing the location of each damper on the floor plans.

3.4. DEMONSTRATION

A. Demonstrate re-setting of fire dampers for Owner and Engineer.

B. Provide Owner training in compliance with Section 230200.

END OF SECTION

# SECTION 23 37 13 – DIFFUSERS, REGISTERS AND GRILLES

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated, include the following:

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

### 1.3. QUALITY ASSURANCE

A. Comply with NFPA 90A and NFPA 90B.

B. Install flexible diffusion (“fabric”) outlets in accordance with manufacturer’s recommendations.

### 1.4. WARRANTY

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

## PART 2 - PRODUCTS

### 2.1. METAL DIFFUSERS, GRILLES & REGISTERS

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

1. Krueger
2. Metalaire
3. Nailor Industries
4. Price

5. Titus

6. Tuttle & Bailey

B. General Requirements: Devices shall be specifically designed for variable air volume flows. Insulate backpan. Border type shall match each installation. Ceiling, wall, sill or duct-mounting as indicated. Face and neck dimensions as indicated. Inside of each backpan and duct plenum shall be painted flat black so that there is no visible metal from the face.

C. Materials: Provide devices constructed of the following materials unless otherwise indicated.

1. Material: Steel, aluminum, or stainless steel as noted.

2. Finish: Baked enamel, anodized aluminum, or primed-for-paint as noted.

a. Color: White, unless otherwise noted.

D. Volume Dampers: Provide manual volume damper at each air inlet or outlet branch duct tap, whether shown on the drawings or not, regardless of the diffuser, grille or register having an integral damper unless specifically noted otherwise. Dampers shall comply with Section 233300.

E. Fire-Rated Ceiling Assemblies: Provide UL-listed devices designed for integral use in fire-rated assembly ceilings. Do not use the fire damper blades to balance air flow unless specifically noted otherwise. Refer to Section 233300 for additional ceiling radiation fire damper requirements.

## 2.2. SUPPLY AIR DIFFUSERS

A. Square Louvered Face Ceiling Diffuser: Three cone, louvered, full-face diffuser with adjustable vane 360-degree discharge pattern, equalizing grid and foam rubber gasket. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus TMSA series or equal.

B. Drum Louvers: Steel or aluminum frame with extruded aluminum drum and vanes. Individual adjustable spread control vanes housed in a rotatable drum. Drum shall rotate up to 30 degrees off center with locking mechanism for field adjustable drum and vane positions.

## 2.3. RETURN, EXHAUST AND TRANSFER AIR GRILLES AND REGISTERS

A. Square Perforated Face Ceiling Grille: Perforated flush face grille with equalizing grid, foam rubber gasket and pre-formed insulation blanket. Provide backpan with duct connection collar where connected to ductwork. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the diffuser face. Titus PAR series or equal.

B. Standard Blade Grille: Single-deflection, fixed, standard blade grille with front horizontal and rear vertical blades spaced at 3/4-inch. The blades shall be at 0-degree or 35-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 350 series or equal.

C. Filter Grille: Fixed deflection filter return grille with front horizontal blades spaced at 3/4-inch with foam rubber gasket. The blades shall be at 35 to 45-degree deflection as indicated.

Provide 2-inch thick filter frame and hinged grille face with quarter-turn fasteners. Titus 350 series or equal.

D. Heavy Duty Blade Grille: Fixed deflection, heavy-duty grille with front horizontal blades and rear vertical supports at minimum 6-inch spacing. The blades shall be at 0-degree or 35 to 45-degree deflection as indicated. Where indicated, provide opposed-blade neck mounted manual volume damper that is operable from the grille face. Titus 30/33/60/63 series or equal.

## 2.4. SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

# PART 3 - EXECUTION

## 3.1. EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

## 3.2. INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

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

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Diffusers, registers and grilles shall be supported at two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support lay-in ceiling track.

E. Insulate diffusers, grilles and registers to prevent condensation. Coordinate insulation with Section 230713.

1. Insulate the plenum box for all linear and slot supply air diffusers and grilles.

2. Insulate the backpan of all surface-mounted supply air diffusers and grilles.

3. Insulate the backpan of all surface-mounted return / exhaust air grilles and registers where the connected ductwork penetrates the building's thermal and vapor barrier or is routed through unconditioned spaces such as attics, mechanical rooms, basements and crawl spaces.

## 3.3. ADJUSTING

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

END OF SECTION

# SECTION 23 41 00 – PARTICULATE AIR FILTRATION – STANDARD EFFICIENCY

## PART 1 - GENERAL

### 1.1. SUMMARY

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

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product indicated include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

### 1.3. QUALITY ASSURANCE

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

B. Comply with NFPA 90A and NFPA 90B.

C. Filters shall be compatible with Ultraviolet Germicidal Irradiation (UVGI) lamps where UGVI lamps are specified for use in air handling units. Do not use synthetic filters in instances where UVGI lamps are specified.

### 1.4. EXTRA MATERIALS

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

1. Provide two (2) complete set(s) of filters for each filter bank.

## PART 2 - PRODUCTS

### 2.1. GENERAL REQUIREMENTS

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

1. Airguard
2. American Air Filter (AAF) / Flanders
3. Camfil (Farr)

B. Filter Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks. Frames shall provide an airtight fit with the enclosing ductwork. All joints between filter segments and enclosing ductwork shall have gaskets or seals to provide a positive seal against air leakage.

## 2.2. PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, UL 900 Class 2, disposable air filters with holding frames. Media shall be interlaced glass or synthetic fibers coated with non-flammable adhesive. Filter-media frame shall be cardboard sealed or bonded to the media.

1. 1-inch, MERV-8 with maximum initial resistance of 0.45-inches w.g. at 500 fpm and 0.25-inches w.g. at 300 fpm.
2. 2-inch, MERV-8 with maximum initial resistance of 0.25-inches w.g. at 500 fpm and 0.15-inches w.g. at 300 fpm.
3. 1-inch, MERV-9 with maximum initial resistance of 0.40-inches w.g. at 500 fpm and 0.25-inches w.g. at 300 fpm.
4. 2-inch, MERV-9 with maximum initial resistance of 0.30-inches w.g. at 500 fpm and 0.15-inches w.g. at 300 fpm.
5. 1-inch, MERV-13 with maximum initial resistance of 0.30-inches w.g. at 300 fpm.
6. 2-inch, MERV-13 with maximum initial resistance of 0.30-inches w.g. at 500 fpm and 0.16-inches w.g. at 300 fpm.
7. 4-inch, MERV-13 with maximum initial resistance of 0.20-inches w.g. at 500 fpm.

## 2.3. BULK MEDIA

A. Description: Commercial-grade air-filter synthetic media, UL 900 Class 2, factory rolled for temporary uses during construction outside unit filter frames.

1. 2-inch, MERV-13 with maximum initial resistance of 0.40-inches w.g. at 500 fpm.
2. 1-inch, MERV-6 with maximum initial resistance of 0.25-inches w.g. at 500 fpm.

## 2.4. SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of aluminum with flanges to connect to duct or casing system.

B. Prefilters: Integral tracks to accommodate disposable filters at depths indicated.

C. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices and arranged so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.5. FILTER GAGES

A. Description: Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0 to 2.0-inches w.g. and accurate within 3 percent of the full-scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.2. CLEANING

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

END OF SECTION

# SECTION 23 62 13 – PACKAGED ROOFTOP UNITS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes packaged rooftop style units.

### 1.2. PERFORMANCE REQUIREMENTS

A. Heating and cooling efficiencies shall be based on AHRI Standard 340-360.

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

### 1.3. SUBMITTALS

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

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

B. Close-Out Submittals:

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

### 1.4. QUALITY ASSURANCE

A. Efficiencies shall comply with the State Energy Conservation Code.

B. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

D. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

1.5. COORDINATION

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

B. Coordinate sizes, weights (operational and shipping) and locations of supports and opening with the actual equipment provided, including:

1. Concrete bases
2. Structural steel support members
3. Ducting curbs
4. Wall openings

1.6. WARRANTY

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

1.7. EXTRA MATERIALS

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

1. Filters: Two set(s) for each packaged rooftop unit.
2. Fan Belts: Two set(s) for each packaged rooftop unit fan.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

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

1. Electric Cooling with Electric, Gas and Heat Pump Heating Options, 3 to 10 tons:
   a. Carrier (WeatherMaker series).
   b. Daikin/McQuay (Maverick I series).

c. Dunham-Bush (ACPSJ series).

d. Trane Company (Precedent series).

2.2. GENERAL

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

2.3. UNIT CASINGS

A. Casing Fabrication (25 tons and smaller): Factory-fabricated and constructed wall, roof and floor single-wall galvanized steel casing panels with 1/2-inch (R-4) closed-cell insulation with foil-faced interior finish and sealed edges within formed galvanized steel channel framing. No through-metal casing thermal breaks. All joints shall be water-resistant sealed.

B. Casing Finish: Factory-applied prime-coat and thermosetting top-coat enamel rated for a minimum of 500 hours consecutive salt-spray test per ASTM B117.

C. Access Doors: Factory-fabricated double wall, to match casing and insulation materials, finish and performance and suitable for unit pressure and leakage classification.

1. Door Hinges, Latches and Handles: Minimum of two ball-bearing or piano hinges, two wedge-lever latches and steel quarter-turn handles.

2. Door Gaskets: Neoprene gasket around entire perimeter of door frames.

D. Condensate Drain Pans: Factory-fabricated, insulated, stainless steel, water-tight sealed, minimum 2-inches deep drain pans sloped in two directions to collect condensate from cooling coils (including coil piping connections, coil headers and return bends) and humidifiers and direct water toward drain connection. Pan shall extend downstream of coil face to comply with ASHRAE 62.1. Drain connection shall be on the bottom side and at the lowest point on the pan. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

E. Base Rails: Galvanized or stainless steel rails, to match the exterior casing material, for mounting on roof curb or pad as indicated.

F. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

G. Ducting Curbs: Factory-fabricated, insulated, full-perimeter curb of sheet metal, minimum 14-inches high, with neoprene sealing strip, and welded Z-bar flashing. Fully insulate the internal perimeter of the curb with 2-inches (R-10) of polyisocyanurate board insulation. Insulation shall be mechanically fastened to the sheet metal

H. Intake and Discharge Hoods: Factory-fabricated, galvanized steel intake and discharge weather hoods with bird screen and finish to match unit casing.

I. Intake and Discharge Louvers: Galvanized steel intake and discharge louvers with bird screen and finish to match unit casing. Louvers shall be rated for the beginning of water penetration of 0.01 ounce/sqft. free area at 1000 fpm or higher.

2.4. FAN, DRIVE AND MOTOR SECTION

A. Unit shall be equipped with supply, return and exhaust / relief air fans and capable of control functions as indicated.

B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Shafts shall be designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

1. Fans shall be variable speed for single zone VAV operation.

C. Centrifugal Fan Housings: Formed and reinforced steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell. Attach housing to fan-section casing with metal-edged flexible duct connector complying with Section 233300.

D. Fan Wheels:

1. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

2. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

3. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Fan Shaft Bearings:

1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings, L50 rated for 200,000 hours with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.

F. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.

G. Variable Speed Drives: Comply with the requirements of Section 230514. Drives manufactured by the air handling unit manufacturer are also acceptable in addition to the manufacturers listed in Section 230514.

H. Motors: Comply with requirements of Section 230513.

2.5. REFRIGERATION SYSTEM

A. Description: Factory assembled and tested, air cooled; consisting of compressors, condenser coils, condenser fans and motors, and controls.

B. Compressor: Direct-drive, hermetic scroll-type compressors designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

1. Capacity Control: Variable speed compressor for capacity control with continuous dehumidification on a single compressor.

2. Filter Drier: Removable core filter driers on each refrigerant circuit.

C. Refrigerant: R-407C, R-410A, or R-134A.

D. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including sub-cooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant. Provide with condenser coil hail guard and factory-applied corrosion resistant coating rated for a minimum of 5,000 hours consecutive salt-spray test per ASTM B117.

E. Condenser Fans: Propeller-type vertical discharge; direct-driven, permanently lubricated, ball-bearing motors for each fan, dynamically and statically balanced fan assemblies.

F. Operating and Safety Controls:

1. Manual-reset, high-pressure cutout switches.

2. Automatic-reset, low-pressure cutout switches.

3. Low-oil-pressure cutout switch.

4. Compressor-winding thermostat cutout switch.

5. Three-leg, compressor-overload protection.

6. Magnetic contactors for compressor and condenser fan motors.

7. Timer to prevent excessive compressor cycling.

2.6. GAS HEAT EXCHANGER

A. Description: Factory-assembled, piped and wired gas-fired heat exchanger and burner, UL approved, and complying with the requirements of NFPA 54. Heat exchanger shall be tubular two-pass stainless steel factory pressure and leak tested. Burner shall be stainless steel with an air proving switch. Ignition shall be electronically controlled electric spark with flame sensor. Burner assembly shall house ignition and monitoring electrode. Combustion blower shall be centrifugal fan with motor with built-in thermal overload protection. Heat exchanger shall have a stainless steel drain pan.

B. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Full modulating, condensing type, with a minimum turndown of 2:1.

C. Combustion Efficiency: Minimum 80 percent.

D. Venting: Power vented with integral, motorized centrifugal fan interlocked with gas valve.

E. Safety Controls:

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

2.7. HEATING AND COOLING COILS

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

B. Hot Gas Reheat Coils: Hot gas reheat coil circuiting and controls shall modulate reheat for dehumidification control.

2.8. ULTRAVIOLET GERMICIDAL IRRADIATION LAMPS

A. Ultraviolet Germicidal Irradiation (UVGI): Ultraviolet radiation shielded (UV-C) lamps that are UL listed for disinfection in HVAC applications. The UVGI system shall be located for maximum effectiveness and to constantly irradiate the surfaces of the cooling coil and drain pan with a 90% efficiency. Light fixture shall be constructed of stainless steel and suitable for operation in saturated air.

1. Automatic Disconnect: UVGI system shall automatically switch off when the unit access door is opened.
2. Interlocked Disconnect: UVGI system shall automatically switch on when the unit supply fan is operating and off when it is not.
3. Manual Disconnect: UVGI system shall have a unit-mounted manual disconnect switch to turn lights off for testing and maintenance while air handler is in operation. Label switch in compliance with Section 230553.

   UVGI DISCONNECT SWITCH
   DANGER: TURN UVGI LAMPS OFF
   BEFORE ENTERING AHU.

   INTERRUPTOR DE DESCONEXION DE LAMPARAS
   DE IRRADIACION GERMICIDA ULTRAVIOLETA (UVGI)
   PELIGRO: APAGUE LAS LAMPARAS (UVGI)
   ANTES DE ENTRAR UTA (AHU).

4. Access Door View Panel: View panel glass in access section with UVGI system shall be ultraviolet light filtering to allow inspection from outside the unit while in operation.

5. UVGI Lamps: UV-C radiation lamps that emit minimum 85% of 253.7 nm wave length; do not generate ozone; and are rated for minimum lamp life of 9000 hours. Lamps shall be hermetically sealed within a thin layer of UV-C transmissible Teflon® to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.

6. Warning Sign: Post warning signs on access doors that are exposed to UV light as follows: "Caution: Ultraviolet energy. Protect eyes and skin. Do not switch off safety button or activate lamps with door open."

   a. Apply warning signs on the access door used to access UV-C lamps and the next door upstream and downstream.

      WARNING: ULTRAVIOLET LIGHT HAZARD.
      DIRECT EXPOSURE TO UV-C LIGHT PRODUCED BY UVGI LAMPS MAY RESULT IN EYE AND SKIN DAMAGE.
      NEVER LOOK AT LAMPS WHILE THEY ARE LIT.
      DO NOT DISABLE SAFETY DEVICES.
      DISCONNECT UVGI POWER BEFORE SERVICING.

      PELIGRO: PELIGRO LUZ ULTRAVIOLETA.
      EXPOSICION DIRECTA A RADIACION UV-C PRODUCIDA POR LAS LAMPARAS UVGI PUEDE RESULTAR EN DAÑOS A LOS OJOS Y PIEL.
      NUNCA MIRE LAS LAMPARAS MIENTRAS ESTÁN ENCENDIDAS.
      NO DESACTIVE LOS DISPOSITIVOS DE SEGURIDAD.
      DESCONECTE EL PODER DEL UVGI ANTES DE REPARAR.

2.9. AIR FILTRATION SECTION

A. Filters: Filter sections shall be designed for the indicated filter types and orientations. Where not indicated, provide housings and frames for angled 2-inch deep filters.

B. Filter Holding Frames: Provide filter holding frames arranged for flat or angled orientation, with access doors on both sides of unit. Filters shall be removable from either side.

2.10. DAMPERS

A. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, aluminum dampers mechanically fastened to cadmium-plated steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

B. Isolation Dampers: Comply with Section 233300.

C. Leakage Rate: Damper leakage rate shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential based on AMCA 500.

D. Damper Operators: Comply with Section 230900.

2.11. ELECTRICAL SYSTEM

A. Power Supply: Single-point external power connection with a unit-mounted non-fused disconnect switch. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 65,000A at 480V.

B. Disconnect Switch: Provide separate unit mounted disconnect switch complying with Section 230511.

C. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch length of liquid-tight or flexible metallic conduit.

D. Factory installed and wired, and functionally tested at factory before shipment.

E. Variable Frequency Controllers: Variable frequency drives shall be mounted within dedicated pre-manufactured casing compartment. They shall not be installed outdoors without supplemental cooling. Comply with the requirements of Section 230514.

2.12. CONTROLS

A. Packaged Controls: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power. Control status display shall be factory mounted to the unit. Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions. Control equipment and control valves as specified in Section 239010.

1. Standalone control sequences shall include:

a. Single-zone, variable volume air flow.

b. Discharge temperature, variable volume air flow.

c. Enthalpy economizer.

d. Dry bulb economizer.

e. Barometric relief damper modulation.

f. Ventilation override mode (for smoke purge, pressurization and exhaust modes).

g. Refrigerant coil defrost mode.

h. Condensate drain pan overflow switch safety.

B. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display packaged rooftop status and alarms.

1. BACnet per ASHRAE 135 communication interface with the BAS shall enable the BAS operator to remotely control and monitor the packaged rooftop units from an operator workstation. All control features and monitoring points displayed locally at packaged rooftop unit control panels shall be available through the BAS.

C. Control Dampers: Refer to Section 233300.

D. Damper Operators: Refer to Section 230900.

E. Smoke Detector: Installed in the return air stream with a field connection to the building fire alarm system.

## 2.13. SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 300 and 301. Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210.

C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

D. Steam Coils: Factory tested to 300 psig and to 200 psig underwater according to AHRI 410 and ASHRAE 33.

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

# PART 3 - EXECUTION

## 3.1. EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

## 3.2. INSTALLATION

A. Equipment Mounting:

1. Install units at grade on cast-in-place concrete equipment bases.
2. Install units on roofs on structural steel supports or roof curbs as indicated.
3. Comply with requirements for vibration isolation and wind and seismic control devices specified in Section 230548.

B. Arrange installation of units to provide access space around units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3. CONNECTIONS

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

B. Install piping adjacent to units to allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans and extend to nearest drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Gas Piping: Comply with applicable requirements in Section 222316. Install shutoff valve, union, dirt leg and regulator (as required) at each gas heat exchanger connection.

F. Connect duct to units with flexible connections. Comply with requirements in Section 233300.

3.4. FIELD QUALITY CONTROL

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

B. Packaged rooftop unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5. STARTUP SERVICE

A. Perform startup service per manufacturer’s recommendations.

B. Test all components and controls to verify they operate as intended.

3.6. ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 for air system testing, adjusting, and balancing.

C. Replace fan and motor pulleys as required to achieve design airflow. Coordinate with the TAB Contractor.

3.7. CLEANING

A. After completing system installation and testing, adjusting, and balancing packaged rooftop unit and air-distribution systems and after completing startup service, clean units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8. DEMONSTRATION

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

END OF SECTION

# SECTION 23 82 16 – AIR COILS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes heating and cooling air coils.

### 1.2. SUBMITTALS

A. Product Submittals: For each type of product include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacities, operating characteristics, and pressure drops for each air coil.

### 1.3. QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC).

## PART 2 - PRODUCTS

### 2.1. GENERAL REQUIREMENTS

A. Performance Ratings: refrigerant coils shall be tested and rated according to AHRI 410 and ASHRAE 33. Electric resistance coils shall be listed and labeled according to NFPA 70 and assembled according to UL 1995.

### 2.2. REFRIGERANT COILS

A. Description: Coils shall be factory tested to 450 psig and rated for a minimum working pressure of 300 psig. Coil tubes shall be ASTM B 743 seamless copper expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leak-tight joints. Coil fins shall be copper or aluminum. Suction and distribution piping shall be ASTM B 88, Type L copper tube with brazed joints. Coil casings shall be minimum 16 gauge galvanized steel channel frame for slip-in or flanged mounting.

2.3. DRAIN PANS

A. Description: Drain pans shall be stainless steel. Alternative materials, such as galvanized steel and plastic, are not acceptable. Construct insulated pans with drain connection at the lowest point(s) and comply with ASHRAE 62.1. Pans shall extend beyond coil length and width, upstream and downstream of coil face, and under coil header and exposed piping

PART 3 - EXECUTION

3.1. EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2. INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

D. Install drain pan under each cooling coil. Connect to condensate trap and drainage.

E. Straighten bent fins on air coils.

3.3. CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Refrigerant Coils: Connect refrigerant piping according to Section 232300.

D. Electric Resistance Coils: Ground equipment and connect wiring in accordance with NFPA 70 and Division 26.

END OF SECTION

# SECTION 23 90 00 – BAS GENERAL REQUIREMENTS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes general requirements for control systems.

### 1.2. DESCRIPTION OF WORK

A. The Building Automation System (BAS) contractor shall provide including but not limited to sensors, devices, field controllers and panels, network controllers and servers, front end operator interface, software and any other hardware or software components for a fully functioning BAS system.

B. Provide graphics on the front-end server for each piece of equipment, terminal unit, system, and room pressurization monitor and/or control.

C. Provide BAS Commissioning. The process of ensuring that all building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the owner's operational needs, the installation is adequately documented, and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.

D. BAS Architecture Description:

Provide packaged unit controllers with BACnet interface compatible with Owner's existing Siemens system. Packaged unit controllers shall be integrated into the Owner's existing Siemens Supervisor at the Central Office. Graphics, trends, alarms, etc. shall be located on existing Siemens network level controller and pushed to the supervisor.

Coordinate with existing system manufacturer (Siemens) to facilitate the connection of packaged field controllers and the establishment of communication to the building point of connection (BPOC). Device list, points list, and all other pertinent information shall be turned over to Siemens to facilitate the integration into the existing Siemens front end. Coordinate with Siemens to integrate field controllers into front end and update graphics, trending, and make other necessary modifications to the existing Siemens system.

1. Provide additional hardware and licensing as required to integrate new controllers to existing front end.

### 1.3. SUBMITTALS

A. Qualification Submittals: For installer.

B. Product Submittals:

1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, installation guides, and startup instructions for each type of product indicated.

    a. BAS System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

    b. 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.

    c. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

2. 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.

    a. Bill of materials of equipment indicating quantity, manufacturer, and model number.

    b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

    c. Wiring Diagrams: Power, signal, and control wiring.

    d. Details of control panel faces, including controls, instruments, and labeling.

    e. Written description of sequence of operation.

    f. Schedule of dampers including size, leakage, and flow characteristics.

    g. Schedule of valves including flow characteristics, pressure differentials, and flow coefficients (Cv).

    h. BAS System Hardware:

        1) Wiring diagrams for control units with termination numbers.

        2) Schematic diagrams and floor plans for field sensors and control hardware.

        3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

    i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule and operator notations.

    j. Controlled Systems:

        1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

3) Written description of sequence of operation including schematic diagram.

4) Points list.

k. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

3. Display Graphics: Provide a sample of proposed display graphics for each screen page and a flowchart diagram showing how each screen will be linked to the other. Where there are multiple systems or equipment that are repetitive, it is acceptable to provide one and note it applies to others. For example, one terminal unit screen graphic may be submitted as an example to represent all the terminal units of that type for the project.

a. Owner's Graphic Standards: The owner's graphic standards shall be followed.

4. Provide a complete list of any deviations of submitted products to the specification in this document.

5. Data Communications Protocol Certificates: Certify that each proposed BAS system component complies with ASHRAE 135 (BACnet), ANSI Standard ANSI/CEA-709.1 (LonTalk), or MODBUS protocol specification conformance, as applicable.

6. Listing of Products: Certify that each proposed BAS system component is listed with BACnet Testing Lab (BTL), are marked with "LONMARK Compliant" and display the "LONMARK" logo or have been tested per the Modbus Conformance Testing Program, as applicable.

C. Construction Submittals:

1. Checkout Sheets

a. Prior to startup of any equipment, contractor will provide manufacturer checkout sheets for each piece of equipment.

b. Checkout sheets will contain at a minimum:

1) Equipment name and location.

2) Associated controller address (MAC or Node ID), name, type and instance number.

3) Provide documentation of testing and calibration for each input and output. Submit for Engineer review.

D. Close-Out Submittals:

1. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals, including the following:

a. Maintenance instructions and lists of spare parts for each type of control device.

b. Interconnection wiring diagrams with identified and numbered system components and devices.

c. Keyboard illustrations and step-by-step procedures indexed for each operator function.

d. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

e. Calibration records and list of set points.

f. BAS Checkout Report: Controls system point-to-point checkout list to include the following: all physical points (excluding software points and/or setpoints), technician's initials, and dates of the point checkout.

g. Contractor verification of 100 percent of all control and monitoring points and all control sequences prior to Engineer witness.

2. Software and Firmware Operational Documentation: Include the following:

   a. Software operating and upgrade manuals for all software required to program and maintain the system.

   b. Program Software Backup: On a magnetic media or compact disc, complete with data files.

   c. Device address list.

   d. Printout of software application and graphic screens.

   e. Software license required by and installed for BAS workstations and control systems.

3. Software Back-Up Electronic Files.

1.4. QUALITY ASSURANCE

A. The building automation system (BAS) shall be furnished, engineered, installed, tested and calibrated by factory certified technicians qualified for this work. The contractor shall be factory authorized in good standing with the manufacturer and located within 100 miles of the project site. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request. A full-time on-site experienced project manager for this work shall be responsible for the direct supervision of the installation and start-up of the system.

   1. Upon request, installer shall present records of successful completion of factory training courses.

   2. Upon request, the installer shall provide a letter from the manufacturer that they are a Factory Authorized installer in good standing with the Manufacturer.

   3. Upon request, the installer shall provide a list of 10 projects of similar scope and complexity within the past 5 years with the project owner's contact information.

B. Comply with UL 916 for Energy Management Systems.

C. Comply with UL 864 for Smoke Control System components.

D. Control panels, new and modified, shall comply with UL 508A. Field-built or modified panels shall be inspected, listed and labeled in the field or replaced with an equivalent shop-built panel that is listed and labeled.

E. Comply with ASHRAE 135 for BAS system components.

1. Local and Terminal Control Units shall be BACnet Testing Lab (BTL) listed.

A. Electrical Components, Devices and Accessories: UL listed and labeled as defined by NFPA 70, the National Electric Code, or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

B. Mechanical Equipment and Materials: UL listed and labeled as defined by State Building Codes or equivalent by a qualified testing agency marked for the intended location and application and accepted by the Authority Having Jurisdiction and Engineer.

C. Testing and listing laboratories of mechanical and electrical equipment shall be accredited by the North Carolina Building Code Council (NCBCC). Comply with NC General Statute 66-25.

## 1.5. DELIVERY, STORAGE AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

## 1.6. COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Engineer prior to installation.

B. Coordinate equipment with the fire alarm system to achieve compatibility with equipment that interfaces with that system.

C. Coordinate sources of 120V power with the Electrical Contractor and Owner for control units, operator workstation and other devices. Extend power from sources as needed.

D. Coordinate location of data ports with the Electrical Contractor and Owner.

## 1.7. SEQUENCE OF OPERATION

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

## 1.8. EXTRA MATERIALS

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

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, humidistat and positioning relay.

## 1.9. WARRANTY

A. Building Automation System: Parts and labor for 1 year from the date of completion. The Owner reserves the right to make changes to the BAS during the warranty period and such changes do not constitute a waiver of the warranty.

1. The Owner shall allow remote access to the BAS for diagnostic testing and monitoring during the warranty period.
2. Upon request, a technician shall be on site to resolve the Owner reported issue within 24 hours of it being reported if it has not been resolved remotely to the Owner's satisfaction.

B. Electronic Actuators: Parts and labor for 5 years from the date of completion.

# PART 2 - PRODUCTS

## 2.1. GENERAL REQUIREMENTS

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

1. Alerton (Ascent Series) installed by Hoffman Building Technologies.
2. Distech Controls (BACnet Series) installed by CMS Controls (CMS) or Engineered Control Solutions (ECS) or Hoffman Building Technologies (HBT).
3. Schneider Electric (EcoStructure Building Operation Series) installed by Schneider Electric.
4. Siemens installed by Siemens or CMS Controls (CMS).

B. Products by the BAS system manufacturer shall include user interface, controller software, application programming language and equipment and application controllers. Sensors, actuators, valves, dampers and other components may be manufactured by others as indicated.

## 2.2. GRAPHICS AND REPORTING

A. Floor Plan Graphics:

1. Provide floor plan graphics for all areas of the building(s) served by the BAS. Create floor plans with an appropriate level of detail based on the construction documents. Copying the construction document files is not acceptable as they usually contain too much detail to be legible on a single screen shot. Submit the proposed graphics with the Owner / Engineer for approval.

2. Provide links from floor plans to enlarge floor plan areas (zoom in feature). Provide links from enlarged floor plans to equipment diagrams.

3. Provide links from zone sensor locations on the floor plans to associated terminal equipment. Each temperature control zone shall be clearly indicated on the floor plans.

4. Coordinate room names and numbers with the Owner and building signage. Often the final room names and numbers differ from the construction documents.

B. Equipment / Terminal Unit Graphics:

1. Provide an equipment diagram indicating each component and sensor with a link to the written sequence of operation, maintenance notes, etc. Each diagram shall indicate all data points. Parameters shall be overridden / changed from the graphic.

2. Provide a link to associated equipment for each diagram. (For example, a terminal unit might have a link at the reheat coil to the heating water plant and the terminal box to the AHU feeding it.)

3. Provide a location for any point associated with an equipment diagram but located remotely. For example, a duct-mounted pressure sensor in the AHU diagram might be indicated to be 'Located AFC in 24x12 SA duct in Corridor 100 outside Room 101'.)

4. Terminal Unit Graphics: Typical terminal unit graphics shall include:

   a. Minimum and maximum flow setpoints

   b. Heating flow setpoints

   c. Zone heating and cooling temperature, high and low humidity and carbon dioxide high limit setpoints (if applicable)

   d. Terminal unit percent of maximum heating and cooling

   e. Occupancy control mode and status

   f. Alarm status.

   g. Time and date

   h. Outside air temperature

C. Alarm Reporting:

1. Alarm Tag: Each alarm shall have a unique description tag, date and time. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store each alarm message.

2. Alarm Prioritization: Each alarm type shall be assigned a priority level as defined by the Owner.

3. Alarm Acknowledgment: Each alarm shall be acknowledged by a recipient with password authorization via any form of operator interface. The alarm acknowledgement information including operator, date and time shall be saved with and append the alarm tag.

4. Alarm Summary Logs: Operators shall be able view all alarms and acknowledgements. They shall be sortable by date and time, operator, alarm type, and alarm priority.

5. OWS interface shall monitor all alarms. Alarm notifications shall be automatically sent to Owner staff via email and text messaging based on staff and alarm prioritization. The system's ability to report alarms shall not be affected by a breakdown in communications with other control panels on the network.

6. Alarms shall be defined by the Engineer's sequences of operation and the Owner.

D. Trend Reporting:

1. Trend Tag: Each trend shall have a unique description tag, date and time duration. The tag shall be easily understood without the need to translate abbreviated or coded descriptions. The OWS shall be able to display, print and store trend data.

2. Trend Summary Logs: Operators shall be able view all trend data. They shall be sortable by initiation date and time, operator, trend type.

3. Trend Data Collection: Data shall be exported to a compressed file on the server in MS Excel or MS Access format. Data shall be able to be stored without over-writing the collected data files for no less than one year.

4. Initial trends shall be defined by the Engineer's sequences of operation. Final trends at project completion shall be determined by the Engineer and Owner once the building systems are fully operational and functioning properly.

E. As-Builts:

1. A link to the schematics, wiring diagrams, and sequences of operation in PDF format shall be displayed on the equipment graphic to enable the owner to view them from the graphic interface to assist in troubleshooting of the system.

## 2.3. SURGE PROTECTION

A. Surge Protection Devices: Provide lightening / surge protection devices to protect the BAS system. Ditek (DTK-LVLP series), Emerson Edco (PC642 series), PE manufacturing (DRS series) or equal.

B. Provide surge protection on the following equipment:

1. Critical Control Panels as defined by the Engineer based on submitted controls architecture.

2. Control cable, including but not limited to input/output wiring, communication bus, or any other wire at every point it exits and enters the building.

C. Where a UPS is also being provided, it may be combined with the surge protection requirements.

## 2.4. CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring shall comply with Section 230511 and Division 26.

2.5. ELECTRICAL CONNECTIONS AND ENCLSOSURES

A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.

B. Comply with the requirements of Section 230511 and Division 26.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Work and/or systems installed under this Division shall be fully functioning prior to demonstration and acceptance. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below.

B. Verify that power supply is available to control units and operator workstation.

C. Verify that duct, pipe, and equipment-mounted devices are installed before proceeding with installation.

3.2. HARDWARE AND SOFTWARE INSTALLATION

A. Install software in NCUs, Operator Workstation(s), Server(s), as required, and in accordance with 239030. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

1. Sequence of operation programming shall exist on the controller level with default values set to allow continuous, stable system operation in case of network failure.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Graphics: The web browser view of the graphics shall be the same as provided by the Operator Interface Graphic Software when accessed directly on the Owner's network. The web browser graphics shall support URL hypertext links for other locations on the internet and intranet.

1. All graphic screens shall indicate date, time, and outside air temperature, and outside air relative humidity.

2. All valves and dampers shall display position as percent open.

D. Trending: Unless otherwise noted on construction documents or points lists the following points should be trended at the defined intervals:

1. Analog Inputs: 15 Minute (Max) Interval.

2. Analog Outputs: 15 Minute (Max) Interval.

3. Setpoints: COV and at least once every 24 hours.

4. Digital points: COV and at least once every 24 hours.

## 3.3. ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor or Owner.

B. Install raceways, boxes, and cabinets according to Section 230511 and Division 26.

C. Install building wire and cable according to Section 230511 and Division 26.

D. Install signal and communication cable according to Section 230511 and Division 26. Comply with manufacturer's installation guidelines.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

2. Install exposed cable in raceway.

3. Install concealed cable in raceway.

4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

G. Install surge protection in accordance with manufacturer's guidelines.

## 3.4. FIELD QUALITY CONTROL

A. Description: Inspect, test, verify and demonstrate equipment, control components and sequences of operation device-by-device and line-by-line for Engineer approval prior to Owner Acceptance.

1. Coordinate efforts with the Owner, Engineer, Commissioning Agent (if applicable), Construction Manager, Mechanical Contractor, Fire Alarm Contractor and TAB Contractor.

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

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by BAS system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.

6. Test Results: Record test results and submit copy of test results for Project record.

3.5. BAS SYSTEM VERIFICATION

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. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.

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 is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.
7. Verify fail position, stroke and range is correct.

F. 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 flow instruments, verify that recommended upstream and downstream distances have been maintained.
7. For temperature instruments:
   a. Verify sensing element type and proper material.
   b. Verify length and insertion.

3.6. BAS 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 a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.7. BAS SYSTEM I/O TESTING, ADJUSTING AND CALIBRATION

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a 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 a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Check each instrumentation device by making a comparison between the BAS display and the reading at the device. Record the measured value and displayed value for each device in the BAS Checkout Report.

G. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

H. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

I. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

J. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

K. 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.

L. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.
3. Check each digital input point by making a comparison between the BAS display and the state of the sensing device. Record the results for each device in the BAS Checkout Report.

M. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 50 percent open, to 100 percent closed, to 50 percent closed, and back to 100 percent open.

2. Check and document open and close cycle times for applications with a 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.

4. Check each control damper by making a comparison between the BAS display and the position at the device. Record the commanded damper, actual position, and position feedback when applicable for each device in the BAS Checkout Report.

5. If actual damper position doesn’t reasonably correspond, replace actuator.

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.

Q. Exercise each binary point.

R. For every I/O point in BAS system, read and record each value at operator workstation, at BAS controller and at field instrument simultaneously. Value displayed at operator workstation, at BAS controller and at field instrument shall match. Report results in BAS Checkout Report.

S. Prepare and submit a BAS Checkout Report documenting results for each I/O point in BAS system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

## 3.8. BAS CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to BAS 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 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. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Checkout Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):

   a. Duct air temperature: Plus or minus 1 deg F.

   b. Space Temperature: Plus or minus 2 deg F.

   c. Duct or space Humidity: Plus or minus 5 percent.

   d. Air flow control: Plus or minus 5 percent of setpoint velocity.

7. Test software and hardware interlocks for proper operation. Correct deficiencies.

8. Operate each analog point at the following:

   a. Upper quarter of range.

   b. Lower quarter of range.

   c. At midpoint of range.

## 3.9. BAS 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 approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test 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 BAS system components, wiring, and accessories are installed.

5. Installed BAS 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. BAS 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 graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of BAS system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in BAS system.

a. Verify analog I/O points at operating value.

b. Make adjustments to out-of-tolerance I/O points.

1) Identify I/O points for future reference.

2) Simulate abnormal conditions to demonstrate proper function of safety devices.

3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.

3. Readjust settings to design values and observe ability of BAS system to establish desired conditions.

4. After 24 Hours following Initial Validation Test:

a. Re-check I/O points that required corrections during initial test.

b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

a. Re-check I/O points that required corrections during second test.

b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that BAS system performs according to requirements indicated.

7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. BAS System Network Bandwidth Test:

1. Test network bandwidth usage on all BAS system networks to demonstrate bandwidth usage under BAS system normal operating conditions.

2. To pass, none of BAS system networks shall use more than 70 percent of available bandwidth under normal operation.

## 3.10. BAS SYSTEM WIRELESS NETWORK VERIFICATION

A. BAS system Installer shall design wireless BAS system networks to comply with performance requirements indicated.

B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.

C. Testing and verification of all wireless devices shall include, but not be limited to, the following:

1. Speed.

2. Online status.
3. Signal strength.

3.11. FINAL REVIEW

A. Submit written request to Engineer and Construction Manager when BAS system is ready for final review. Written request shall state the following:

   1. BAS system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. BAS system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. BAS system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. BAS system is complete and ready for final review.

B. Review by Engineer and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, BAS system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by BAS system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals.

F. BAS system final review shall include a demonstration to parties participating in final review.

   1. Coordinate the demonstration 2 weeks in advance with representatives of the Owner, Engineer, Commissioning Agent (if applicable), Construction Manager, Mechanical Contractor, Fire Alarm Contractor and TAB Contractor.
   2. Provide staff familiar with BAS system installed to demonstrate operation of BAS system during final review.
   3. Provide testing equipment to demonstrate accuracy and other performance requirements of BAS system that is requested by reviewers during final review.
   4. Demonstration shall include a detailed review of the control sequences for each system and piece of equipment.

3.12. EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of BAS system by Owner.

B. Operate BAS system for an operating period of 28 consecutive calendar days following project completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with BAS system installed to man an operator workstation.

D. During operating period, BAS system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
2. Downtime is when any I/O point in BAS system is unable to fulfill its' required function.
3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
4. Maximum time interval allowed between BAS system detection of failure occurrence and operator confirmation shall be 0.5 hours.
5. Downtime shall be logged in hours to nearest 0.1 hour.
6. Power outages shall not count as downtime but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:
    a. Time of occurrence.
    b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
    c. Downtime for each failed I/O point.
    d. Running total of downtime and total time of I/O point after each problem has been restored.
5. Log shall be available to Owner for review at any time.

G. For BAS system to pass extended operation test, total downtime shall not exceed 1-percent of total point-hours during operating period.

1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until BAS system passes requirement.

H. Evaluation of BAS system passing test shall be based on the following calculation:

1. Downtime shall be counted on a point-hour basis where total number of BAS system point-hours is equal to total number of I/O points in BAS system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test when BAS system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 hr/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

## 3.13. ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of project completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other-than-normal occupancy hours for this purpose.

## 3.14. MAINTENANCE SERVICE

A. Maintenance Service: Beginning at project completion, maintenance service shall include 12 months' full maintenance by BAS system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

## 3.15. SOFTWARE BACK-UPS

A. Upon completion including final adjustments, backup all data to associated NCUs and/or front-end servers/supervisors.

B. All software required to operate, maintain, and program the system becomes the property of the owner.

## 3.16. SOFTWARE UPDATES

A. At 12-months from the date of completion, update the BAS software to the most recent release. The update(s) shall be scheduled with the Owner and performed under their direct supervision. Verify proper operation after the installation and correct any problems created by the installation process.

1. Software update shall include all labor, licensing and associated fees.

2. If the Owner has an established energy management system serving buildings outside the scope of this project, ensure the software is compatible with the existing system without needing to update it.

3.17. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Training will provide site specific information including but not limited to:

1. As-builts.

2. BAS checkout, startup and calibration report.

3. Controller replacement.

4. Software required to manipulate the system including programming.

END OF SECTION

# SECTION 23 90 10 – BAS INSTRUMENTATION

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes instrumentation for building automation systems.

### 1.2. SUBMITTALS

A. Comply with the requirements of Section 239000.

B. Product Submittals: Provide data for product indicating compliance with the requirements of this project.

C. Close-Out Submittals:

1. Operation and Maintenance Data: For instrumentation to include in operation and maintenance manuals.

### 1.3. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

### 1.4. COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Engineer prior to installation.

B. Coordinate sources of 120V power with the Electrical Contractor and Owner for control devices. Extend power from sources as needed.

### 1.5. WARRANTY

A. Warranty: Provide one-year manufacturer's parts and labor warranty for each energy and flow meter.

1. Electronic Actuators: Parts and labor for 5 years from the date of completion.

### 1.6. EXTRA MATERIALS

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

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, thermostat, humidistat and positioning relay.

PART 2 - PRODUCTS

2.1. SENSORS

A. Provide sensors as indicated in control diagrams and sequences of operation or as needed to perform the intended operations.

B. Sensors shall be vibration and corrosion resistant and designed for the intended use.

2.2. TEMPERATURE SENSORS, STANDARD ACCURACY

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

1. Automation Components Inc. (ACI)
2. Building Automation Products Inc. (BAPI)
3. Distech
4. Honeywell
5. Johnson Controls Inc. (JCI)
6. Siemens

B. Description: Temperature sensor shall be thermistor or resistance temperature detector (RTD) type and compatible with BAS.

1. Accuracy: Plus or minus 0.5 deg F over 32 to 158 deg F range.
2. Operating Temperature: Minus 40 to 300 deg F.

C. Wall-Mounted Temperature Sensor: Sensors in white plastic enclosure with insulated backing.

1. LED display.
2. Set point adjustment.
3. Push button occupancy override switch.

D. Wall-Mounted Flat-Plate Temperature Sensor: Stainless steel, flat plate sensor that fits in a standard 2-inch by 4-inch junction box with tamperproof screws. Provide with insulated backing.

E. Outside Air Temperature (OAT) Sensor: Thermistor or RTD compatible with BMS installed in wall-mounted weatherproof enclosure with conduit entrance and aluminum LB with PVC sun and windscreen.

F. Duct-Mounted Single-Point Temperature Sensor: Rigid sensor sealed in 0.25-inch stainless steel probe of length between one-third and two-thirds of the duct width in duct-mounted metal housing with conduit entrance.

1. Single-point may be used in ducts where there is no air stratification possibilities. Sensor shall be mounted downstream to allow for sufficient mixing.

G. Duct-Mounted Averaging Element Temperature Sensor: Multi-point sensor, contained in a flexible copper or woven continuous metallic sheath, with length sized for duct.

1. Provide a minimum of 1 foot of sensing element for every 3 square-feet of duct/coil area. Multiple averaging elements may be required.
2. Averaging elements shall be used where ducts are prone to stratification, and downstream of heating/cooling coils.
3. Where multiple sensors are provided, sensors may be wired in a series-series, parallel-parallel pattern (requires four or nine sensors) in lieu of multiple inputs.
4. Plenum rated sheaths are not acceptable.

2.3. THERMOSTATS

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

1. Automation Components Inc. (ACI)
2. Honeywell
3. Johnson Controls Inc. (JCI)
4. Schneider Electric

B. Digital Stand-Alone Thermostat: Electric, solid-state, microcomputer-based room thermostat.

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day, with individual programming for each day of the week (4 programs per day, 7 days per week, 28 potential programs).
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Short-cycle protection.
6. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable and fan on-auto.
7. Powered off unit 24Vac transformer, with solid-state memory in which programming is retained on power failure. Battery acceptable only for time and date upkeep during power failure.
8. Thermostat display features include the following: time of day, actual room temperature, programmed temperature, programmed time, duration of timed override, day of week, and system mode indications include "HEATING", "OFF", "FAN AUTO" and "FAN OFF".

9. Combination Thermostat, Humidistat, Carbon Dioxide, and/or Occupancy Sensor: Where there is a requirement for a thermostat with humidistat, carbon dioxide, and/or occupancy sensing functions at the same location, provide combination unit. The individual sensors must each meet the specifications details herein.

10. Provide remote sensing element (electronic sensor) as required for application.

C. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sqft. of coil surface.

D. Electric High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual automatic reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sqft. of coil surface.

2.4. HUMIDITY SENSORS, STANDARD ACCURACY

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

1. Automation Components Inc. (ACI)

2. Building Automation Products Inc. (BAPI)

3. Distech

4. Honeywell

5. Johnson Controls Inc. (JCI)

6. Siemens

B. Description: Laser-trimmed thermoset polymer-based capacitive-type sensor, 4-20mA or 0-10Vdc output proportional to relative humidity range of 0% to 100% and compatible with 24 Vac/dc power supply and BAS.

1. Accuracy: Plus or minus 3-percent over 10 to 90-percent range.

2. Measurement Range: 0 to 100-percent.

3. Operating Temperature: Minus 40 to 140 deg F.

C. Wall-Mounted Relative Humidity Sensor: Sensors in white plastic enclosure with insulated backing.

D. Outside Air Relative Humidity (OAH) Sensor: Sensor installed in wall-mounted weatherproof enclosure with conduit entrance and aluminum LB with PVC sun and windscreen.

E. Duct-Mounted Relative Humidity Sensor: Sensor with 9-inch long probe in duct-mounted plenum-rated housing with conduit entrance.

## 2.5. COMBINATION SENSORS

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

1. Automation Components Inc. (ACI)
2. Building Automation Products Inc. (BAPI)
3. Distech
4. Honeywell
5. Johnson Controls Inc. (JCI)
6. Siemens
7. Vaisala

B. Combination Wall-Mounted Temperature and Humidity Sensors: Sensors in white plastic enclosure with insulated backing.

1. Where monitoring temperature and relative humidity are required at the same location, provide combination relative humidity and temperature sensors. Individual sensors must meet each of the specification details herein.
2. Where required, combination relative and humidity sensors shall have the ability to output additional parameters including dew point, enthalpy and wet bulb temperature.
3. LED display.
4. Set point adjustment.
5. Push button occupancy override switch.

C. Combination Duct-Mounted Temperature and Humidity Sensors:

1. Where monitoring temperature and relative humidity are required at the same location, provide combination relative humidity and temperature sensors. Individual sensors must meet each of the specification details herein.
2. Where required, combination relative and humidity sensors shall have the ability to output additional parameters including dew point, enthalpy and wet bulb temperature.

## 2.6. DRY (AIR) PRESSURE SWITCHES

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

1. Cleveland Controls
2. Dwyer

B. General Requirements: Diaphragm pressure switch with SPDT contacts and setpoint adjustment knob. Sensor shall be uni-directional and be manual or automatic reset in accordance with drawings.

1. Accuracy: Plus or minus 2 percent of full scale output.

2. Measurement Range: 0 to 0.25-inches wg for building and duct pressurization applications; 0 to 1.50-inches wg for filter alarms; and 0 to 12-inches wg for high static alarms.

    a. Status Inputs for Fans: Adjustable range of 0 to 6-inches wg.

3. Operating Temperature Range: -4 to 185 deg F.

C. “Paddle-style” air flow switches are not allowed. Use dry pressure switch in lieu of paddle.

2.7. DRY (AIR) FLOW SWITCHES

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

1. McDonnell & Miller

B. General Requirements: Explosion proof air flow paddle SPDT switch suitable for Class 1, Division 1 or Division 2 hazardous classified areas.

C. Ambient temperature 120 deg F max, media temperature 275 deg F max.

D. Select switches for appropriate flow and velocity ranges.

E. Provide intrinsic safety barriers, wiring, and seals.

2.8. RELAYS

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

1. Functional Devices

2. IDEC

3. Veris

B. General Requirements: Relays shall be electrically rated for each application, minimally SPDT with 10A (resistive) contacts, and plenum rated. They shall include LED indicator light and hand-off-auto (HOA) unless otherwise specified. Relays shall be UL-listed and mounted in NEMA 1 enclosure for indoor applications and NEMA 4 for outdoor.

C. BAS Panel-Mounted Relays: Socket (“ice-cube”) style with mounting base and replaceable relay. Relays in panel will be screw terminal terminations; relays with wiring whip from factory are not allowed for panel mounting. HOA not required if controller has internal HOA or output being controlled has HOA (i.e. VFD).

D. Nipple-Mounted Relays: Enclosed relay compatible with conduit knockout. Acceptable for field use. With or without factory-provided wiring whip. HOA not required if output being controlled has HOA (i.e. VFD).

E. Track-Mounted Relays: Acceptable for use in terminal unit control panels. Screw terminal terminations. Track-mounted relays are not to be installed in field unless inside an equipment control panel (no track-mounted relays in electrical boxes). HOA not required if output being controlled has HOA (i.e. VFD).

F. Combination Motor Starter / Current Switch Relays: Allowed only for single-phase equipment and must be mounted such that pilot light is exposed (combination motor starter / current switch relays which install inside of motor starter/VFDs are not allowed). Relay and current switch must each meet the specifications details herein. HOA not required if output being controlled has HOA (i.e. VFD).

## 2.9. CURRENT SENSORS, SWITCHES AND TRANSFORMERS

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

1. Automation Components Inc. (ACI)
2. Setra
3. Veris

B. General Requirements: Devices shall be rated for their associated motor load and voltage, have input and output isolation and have LED indication of status. Devices shall be selected based on application including but not limited to standard 60 hertz motors, variable speed controllers or electronically communicated motors (ECM’s). Devices shall be UL-listed and mounted in NEMA 1 enclosure for indoor applications and NEMA 4 for outdoor.

1. Accuracy: 2 percent of full-scale output.
2. Measurement Range: 0 to 2 times the anticipated current.
3. Operating Temperature Range: Minus 30 to plus 140 deg F.

C. Current Status Switch: Self-powered current switch with normally open (NO) contacts for Go/No Go or On/Off status. Provide with adjustable trip point where applicable.

D. Current Sensor / Transducer: Sensor with 4-20 mA or 0-10Vdc output proportional to current draw.

E. Control Transformers: Transformer with 4-20 mA or 0-10Vdc output proportional to current draw.

## 2.10. DETECTION EQUIPMENT

A. Water Leak Detection Alarm: Adjustable-height multi-point water detection sensor constructed to be corrosion and abrasion resistant and configured for normally open or normally closed as required by the application with 24Vac/dc power supply. Provide remote-mounted sensing probe and cable as needed for each application. Dwyer (WD series) or equal.

1. Temperature: Minus 40 to positive 185 deg F.

B. Condensate Drain Pan Overflow Safety Switch: Low-voltage, float-type safety switch designed for condensate drain pan high-level alarm for unit shutdown and alarming. Little Giant Pump/Franklin Electric (ACS series) or equal.

C. Occupancy Override Switch: Low-voltage wall switch in a standard single-switch back box with momentary switch, green LED “on” indicator light, with white plastic faceplate. Hubbell (LVSM series) or equal.

D. Occupancy Sensor: Dual-technology passive infrared (PIR) and ultrasonic occupancy sensor with adjustable time delay of 5 to 45 minutes, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush wall or ceiling mounting in standard metal outlet box. Provide sensor with LED light to indicate when motion is being detected during test and normal operation. Provide sensor with auxiliary dry contacts. Power supply to the sensor shall be 24Vdc, located within the outlet box and be plenum-rated.

1. Ceiling-Mounted Sensors: Cooper Lighting/Eaton (MicroSet Series), Hubbell (OMNI Series), Leviton (OSC Series), Lutron (LOS C Series) or Watt Stopper (LMDC Series).
2. Wall-Mounted Sensors: Hubbell (LightHAWK2 Series), Lutron (Maestro Series), Watt Stopper (LMDW Series).

## 2.11. STATUS SENSORS

A. Shaft-Mounted Limit Switches: SPDT/DPDT mercury-free, gravity-actuated mechanical switch with adjustable shaft connection.

B. Whisker Limit Switches: SPDT/DPDT mechanical whisker switch with adjustable trim arm.

## 2.12. TRANSFORMERS AND CONTACTORS

A. Control Transformers: Class 2, sized and rated for application. Circuit breaker overcurrent protection; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. Functional Devices TR series or equal.

B. Power Contactors: NEMA ICS 2 AC general purpose magnetic contactor mounted in NEMA 1 enclosure for indoor locations and NEMA 4 for outdoor.

## 2.13. ANNUNCIATION DEVICES

A. Visible Status / Alarm Devices: UL-listed; two color LED lights, with green and red polycarbonate lens and white ABS plastic enclosure, wall-mounted on an aluminum faceplate. Words, for example "Fume Hood (Number) Fan Status", shall be printed in minimum 1/2-inch high letters on the enclosure. Each light shall be steady or flashing as noted. 120V or 24 V as needed. Rockwell Automation (855W series) or approved equal.

2.14. ELECTRONIC ACTUATORS

A. Manufacturers: All valve actuators shall be supplied from a single manufacturer. All damper actuators shall be supplied from a single manufacturer. Provide actuators manufactured by one of the following:

1. Belimo
2. Honeywell
3. Johnson Controls Inc. (JCI)
4. Schneider Electric (TAC Dura-Drive)
5. Siemens

B. General Requirements: Direct-coupled type, motor-operated, electric and electronic actuators designed for minimum 60,000 full-stroke cycles at rated torque.

1. Voltage: 24Vac unless otherwise specified. 120V actuators may be allowed if coordinated by controls contractor with electrical contractor to provide local disconnect and power. Circuit must be fed from the same power panel as the equipment or control panel and a spare circuit must be available.
2. Power: Contractor is responsible for sizing control transformers based on the VA of the actuator(s) selected. Provide electronic overload protection throughout the entire operating range in both directions.
3. Coupling: V-bolt and V-shaped, toothed cradle. Bolt and set screw method of attachment is unacceptable.
4. Fail-Safe: Where indicated, provide actuator to fail via a mechanical spring return mechanism, to drive controlled device to an end position (open or close) on loss of power. Electronic fail-safe is not allowed, unless specifically reviewed and accepted by Engineer. Provide external, manual gear release on non-spring-return actuators.
5. Temperature Rating:
    a. Standard Dampers and Valves: Minus 22 to plus 122 deg F.
    b. Smoke Dampers: Minus 22 to plus 250 deg F.
6. Housing: Minimum NEMA Type 2, mounted in any orientation, for indoor locations and NEMA Type 3R, mounted in any orientation, for outdoor locations.
7. Stroke Time:
    a. Normal: 120 seconds or less from fully closed to fully open, or fully open to fully closed.
    b. Fast-Acting: 12 seconds open, 5 seconds closed unless otherwise noted.

8. Actuators shall operate related valve(s)/damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the valve/damper is subjected.

9. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the designed pump/fan shutoff pressure as a minimum requirement.

10. Select actuators to fail in desired position in the event of a power failure. See drawings for power failure modes.

11. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

12. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

13. Provide actuator enclosure with a heater and controller where required by application.

14. Comply with requirements in Section 230513.

C. Two-Position Actuators: Single direction, spring return or reversing (non-spring return) type.

D. Modulating Actuators:

1. Capable of stopping at all points across full range and starting in either direction from any point in range.

2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input, the actuator remains in the last position.

b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero to 5-, zero- to 10-, 1 to 5- or 2- to 10-Vdc and 4- to 20-mA signals.

3. True Proportional Analog Signals: The following space types shall use true proportional analog signals which do not require periodic re-initialization. Verify exact spaces with Engineer.

a. Hospitals: Operating, delivery, procedure, imaging, decontamination and sterile processing, isolation, pharmacies, laser eye, catheterization labs, cystoscopic, trauma, triage, radiology waiting, emergency department waiting, emergency department decontamination, autopsy, bronchoscopy, endoscope cleaning, and lab rooms.

b. Laboratories and support spaces.

4. Floating Control: Floating control actuators shall be allowed only for damper and valve control for room terminal units where there is not a room pressurization requirement. Use of floating controls must be specifically requested by the contractor for specific spaces and reviewed by the engineer. Submission of floating control actuators without specific comment by the contractor for spaces and the resulting review by the Engineer does not constitute approval for use.

5. Pulse width modulation (PWM), or any other analog signal that is not specified above is not allowed.

E. Position Feedback: Where indicated, equip two-position actuators with auxiliary switches (SPDT) for remote monitoring of open and/or closed position. Point of open and/or closed position can be adjusted over the actuators range of operation (0-100%). Where indicated, equip modulating actuators with a position feedback through current and/or voltage signal for remote monitoring.

F. Run Time:

1. Normal: 120 seconds from closed to open or open to closed.
2. Fast-Acting: 12 seconds closed to open and 5 seconds open to closed unless otherwise noted.

## 2.15. CONTROL DAMPERS

A. Refer to Section 233300 for control damper requirements.

## 2.16. ELECTRICAL CONNECTIONS

A. Provide 24V transformers for all control equipment fed by low-voltage (100 to 600 V) power feeders. Coordinate the exact requirements with the Electrical Contractor.

B. Refer to Section 230511 and Division 26 for electrical requirements.

# PART 3 - EXECUTION

## 3.1. GENERAL INSTALLATION

A. Exposed wire nuts, including in plenum, will not be acceptable. All connections will be made inside a rated enclosure.

B. Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

C. Coordinate fire alarm relay connections to the fire alarm system with the fire alarm installer.

D. Verify that duct, pipe, and equipment-mounted devices are installed before proceeding with installation.

E. Install labels and nameplates to identify control components according to Section 230553.

F. Install hydronic instrument wells, valves, and other accessories according to Section 232116.

G. Install refrigerant instrument wells, valves, and other accessories according to Section 232300.

H. Install duct volume-control dampers according to Sections 233113.

I. Install energy and flow meters according to Section 239210.

## 3.2. SENSOR INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor per ADA requirements. The location(s) to be selected by the Engineer. No sensor shall be mounted until the Engineer gives specific location instructions. Do not install sensor(s) on the inside of exterior building walls (including column fur outs) unless explicitly approved by Engineer.

B. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

C. Install outdoor air temperature and humidity sensors on north wall at designated location with sun shield.

D. Install mixing plenum sensors in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip.

E. Install temperature sensors minimum 5-feet downstream of air terminal units.

F. Install high accuracy, duct-mounted combination temperature and humidity sensor where a humidity sensor is specified to be used in humidifier control sequences.

G. Provide thermowells to Mechanical Contractor for installation. Mechanical Contractor to "stub-up" any thermowell which is too long to install directly into piping. Install heat-conducting fluid in thermowell prior to installing sensor.

H. Install heat-conducting fluid where strap-on temperature sensors contact piping. Clean piping prior to installation. Insulate around sensor.

I. Wall Modules:

1. Limit set point adjustment to plus or minus 3 deg F unless otherwise specified on the Drawings.

2. Wall module shall be programmed such that it can be used for TAB support.

J. Sensor Guards: Install aspirating guards on thermostats in the following locations:

1. Building entrances.

2. Public areas.

3. Where indicated.

## 3.3. PRESSURE SENSOR INSTALLATION

A. Supply (Positive) Duct Static Pressure: Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

B. Return (Negative) Duct Static Pressure: Pipe low-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.

C. Room Pressure: Pipe appropriate pressure sensor port (positive space: high pressure, negative space: low pressure) to room. Pipe opposite pressure point to reference outside of room. Connect to stainless steel, metal mesh snubber mounted to white 2-inch by 4-inch plate at locations on drawings.

D. Building Static Pressure: Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through outside air reference kit. Mount kit per manufacturer’s instructions. Pipe high-pressure port to stainless steel, metal mesh snubber mounted to white 2-inch by 4-inch plate at locations on drawings.

E. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ducts. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.

F. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

G. Install differential pressure sensor valve manifolds and eye level, and pipe water from mains down to valve manifold.

## 3.4. AIR FLOW SWITCHES INSTALLATION

A. Install air flow switches with manufacturers recommended straight duct diameters in horizontal ducts with switch located on the top of the duct.

B. Adjust factory settings to actual field conditions.

C. Install on wet-well fans to indicate ventilation operation or failure.

## 3.5. CURRENT SWITCHES / TRANSDUCER INSTALLATION

A. Wire may be “wrapped” around CT to obtain better status indication.

B. CTs requiring commissioning/startup will be done per factory installation instructions.

## 3.6. THERMOSTAT INSTALLATION

A. Install Low-Limit Duct Thermostat (Freezestat, LTD) in ducts and plenums in a serpentine manner horizontally (not vertically) across duct. Support each bend with a capillary clip. The element covers a maximum of 12 inches above and below sensing element. At the bottom of the duct or plenum, the row with the tail end of the sensing element shall be a maximum of 6 inches from the bottom.

## 3.7. RELAY INSTALLATION

A. Relays will be mounted at a location where pilot light is visible from floor.

3.8. ACTUATOR INSTALLATION

A. Wire parallel actuators according to manufacturer's recommendations.

B. Check operation of valve/damper-actuator combination to confirm that actuator modulates valve/damper smoothly throughout stroke to both open and closed positions. Check valve for proper close-off.

C. Damper Actuators:

1. Install automatic dampers according to Section 233300.
2. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation.
3. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees in the open position, manually close the damper, and then tighten linkage.
4. Provide necessary mounting hardware and linkages for actuator installation.
5. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures. Provide access door per specifications for any actuator inside of ductwork.

END OF SECTION

# SECTION 23 90 20 – BAS FIELD CONTROLLERS

## PART 1 - GENERAL

### 1.1. SUMMARY

A. Section includes BAS field controllers.

### 1.2. DESCRIPTION

A. Field Controllers are defined as any intelligent device, provided under any specification Division, by any contractor, which communicates with other Field Controllers or a Network Controller in an intelligent manner, beyond a simple contact closure or analog signal.

B. Clarifications:

C. Field Controllers shall communicate utilizing the following protocol(s):

1. LonTalk, in accordance with the latest ANSI Standard ANSI/CEA 709.1.
2. BACnet, in accordance with the latest ASHRAE Standard 135.

D. Other protocol communication, such as Modbus, shall be acceptable when specifically requested for engineering approval.

E. Field Controllers shall fundamentally communicate via the protocol(s) listed. Field Controllers which communicate over a non-specified protocol and then convert to a specified protocol via a protocol converter, router or gateway are not acceptable.

### 1.3. SUBMITTALS

A. Comply with the requirements of Section 239000.

### 1.4. QUALITY ASSURANCE

A. Comply with BAS general requirements in Section 239000.

B. BACnet Controller Requirements: Certify that the controllers proposed to be provided meet each one of the following requirements:

1. Provide BACnet Controllers that BACnet Testing Laboratory listed (v12 or later) as specified herein:
   a. BACnet Building Controller (B-BC)
   b. BACnet Advanced Application Controller (B-AAC)
   c. BACnet Application Specific Controller (B-ASC)

2. All BACnet Controllers shall use the following communication specifications and achieve performance as specified herein:

    a. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (NCU). Any controller on the MS/TP Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Sub-controllers (aka "slave" controllers) are not acceptable.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Comply with the requirements of Section 239000.

2.2. DDC CONTROLLERS

A. General Requirements

1. DDC Controllers shall be provided for AHUs, MAUs, Chillers, Boilers, Water Systems, Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as needed.
2. The application control program for each controller shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals.
3. All control sequences programmed into the controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

    a. Controller shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

4. Controller shall be 32 bit microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.
5. Controller size shall be sufficient to fully meet the requirements of this specification and the sequence of operations.
6. Each TCU shall have sufficient memory, to support its own operating system and databases, including: control processes, maintenance support applications, custom processes, and manual override monitoring.
7. Each controller shall support monitoring of the following types of inputs and outputs, without the addition of equipment outside the Controller enclosure:

    a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

    b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

    c. Digital outputs of 24 Vac/dc (contact closure).

d. Analog outputs of 4-20 mA and 0-10 Vdc.

8. Controller analog or universal input shall use a 16 bit A/D converter. Controllers with less than 16 bit A/D converters must provide all analog input sensors with 4-20ma transmitters.

9. Controller analog or universal output shall use a 10 bit D/A converter.

10. Each controller shall have a minimum of 10% spare capacity for each point type for future point connection.

    a. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

    b. As a minimum, provide one of each type of point available on the controller.

11. Controllers shall function normally under ambient conditions of 32 to 120 deg F and 5 to 90 percent RH (non-condensing).

12. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

13. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted.

    a. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable.

14. The controller shall receive its real-time data from the NCU controller time clock to ensure LAN continuity.

15. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications.

    a. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein.

B. Local Control Units (LCU): For primary systems (including but not limited to AHU, MAU, chiller, boiler, and water systems.)

1. Controller shall be fully programmable, and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

2. Each LCU shall have sufficient memory to support any required energy management applications or alarm management applications.

3. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

4. LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.

5. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the BAS LAN operator workstation or server.

6. Provide an onboard network communication jack for connection to the network (RJ-45 or equivalent quick connect)

2.3. ANALOG CONTROLLERS

A. Step Controllers: 6 or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
2. Proportional band shall extend from 2 to 20 percent for 5 psig.
3. Authority shall be 20 to 200 percent.
4. Air-supply pressure of 18 psig input signal of 3 to 15 psig, and output signal of zero to supply pressure.
5. Gages: 1 1/2-inch diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

PART 3 - EXECUTION

3.1. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

B. BAS Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Comply with verification requirements of Section 239000.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

## 3.2. ADJUSTING

A. Comply with adjustment requirements of Section 239000.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of project completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to six visits to Project during other than normal occupancy hours for this purpose.

END OF SECTION

# SECTION 260100 - BASIC ELECTRICAL REQUIREMENTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.

B. All sections of Division 26 are interrelated. Where materials are required to complete work associated with equipment in a specific section, but the materials are not specified within that specific section, the requirements for those materials shall be as specified elsewhere in Division 26.

### 1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01:
   1. Submittals.
   2. Coordination drawings.
   3. Record documents.
   4. Maintenance manuals.
   5. Rough-ins.
   6. Electrical installations.
   7. Core-drilling, Cutting and patching.
   8. Inspections.

B. Related Sections: The following sections contain requirements that relate to this section:
   1. Division 26 Section "Basic Electrical Materials and Methods," for materials and methods common to the remainder of Division 26.

### 1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 01 Section "Submittal Procedures".

B. Specific Requirements to Electrical Product Data and Shop Drawing Submittals:
   1. Submittals shall be digital format (e.g. .pdf), newly prepared information, drawn to scale where applicable. Do not reproduce Contract Documents or use Contract Document images in the preparation of submittals.
   2. Submittals shall include a complete bill of materials list of all submitted components with quantities, make and model numbers indicated.
   3. Where submittal images contain multiple items, options, or models, Contractor shall clearly indicate, highlight, or note specific equipment submitted for review.
   4. Any deviations from Contract Documents shall be clearly noted and highlighted, encircled, or otherwise visually identified.

5. Product Data and Shop Drawings are separate items and shall be submitted with separate submittal numbers. Where both Product Data and Shop Drawings are required by the same specification section (i.e. Fire alarm) both items shall be submitted for review at the same time. Product Data and Shop Drawings will be reviewed separately by Engineer, but Engineer reserves the right to withhold review until both items have been received.
6. Submittal Documents Quality: Submittals containing poor quality images will be automatically Rejected and returned to Contractor without review.

C. Substitution of Equivalent Products: Where individual sections require submittal for substitution of manufacturers and products equivalent to those listed under Manufacturers paragraph, submittals shall be in accordance with that section. Engineer has final authority on equivalence and acceptance.
   1. Submittal of Substitution Request Forms are permitted by Prime Bidders only. Substitution Request Forms submitted by a vendor, distributor, or sub-contractor will not be accepted or reviewed.

1.4 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 01 Section "Closeout Procedures." In addition to the requirements specified in Division 01, indicate installed conditions for:
   1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
   2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 COORDINATION DRAWINGS

A. Prepare to scale coordination plans for each electrical room/closet, mechanical room with interior panels, and outdoor equipment yard, indicating all new and existing major electrical equipment and control panels location, concrete bases, doors and openings, structure and walls, dimensions, and clearances. Submit coordination drawings prior to major equipment shop drawing submittals to confirm installation coordination.

B. Indicate new and existing non-electrical equipment, piping and ductwork locations within electrical rooms to confirm electrical vertical and horizontal clearances are maintained.

C. Indicate underground and overhead major conduit runs inside electrical spaces to confirm electrical clearances and bends are maintained, and entry/exit locations into electrical equipment.

1.6 OPERATION & MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01 Section "Closeout Procedures" In addition to the requirements specified in Division 01, include the following information for equipment items:

1. Product data for all equipment installed during construction. Product data shall be manufacturer literature, cut-sheets, and/or catalogs and shall clearly depict manufacturer and model number along with standard features and optional features where applicable.
2. Where available for installed equipment, Contractor shall include manufacturer's published Installation and/or Owner's manuals.
3. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
4. Programming report/summary for all systems with conditional logic programming (i.e. fire alarm, lighting control system, and PLCs)
5. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
6. Warranty Information: Copies of documentation for all additional and secondary warranties shall be included.

## 1.7 DELIVERY, STORAGE, AND HANDLING

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

## 1.8 PROJECT DOCUMENTS

A. Division 26 project documents are diagrammatic in nature and intended to represent complete and functioning systems. If any aspect of the work is undefined or unclear, submit your questions in writing prior to the final addendum deadline as defined in the specifications and/or at the pre-bid conference. If any aspect of the work is undefined or unclear after the final addendum, include the cost for the highest quality solution. The contractor is encouraged to thoroughly review the contract documents and site conditions prior to bidding.

B. Basis of Design Manufacturers: A Manufacturer names and model numbers of equipment and devices noted on drawings and in equipment schedules shall be considered the Engineer's basis of design. Proposed changes to the basis of design shall be submitted to the Engineer for review and approval. The submittal shall include a description of all changes necessary to implement the substitution, including but not limited to electrical and controls connections; dimensions, weights and structural supports; and layout changes necessary to maintain clearances. All changes required to implement a substitution is the responsibility of Contractor at no added cost to the Owner.

C. Listed Manufacturers: Manufacturers listed in the Division 26 specification sections and on drawings must meet all the requirements of the project documents. Equipment from listed manufacturers that do not meet the requirements will not be accepted. The manufacturer listing does not result in an automatic approval. In addition to construction, materials and performance requirements, the proposed equipment must meet the indicated physical dimension, clearances, weight, power and controls limitations of the project. Verify existing conditions in the field, when applicable, and proposed conditions prior to submitting equipment for Engineer review.

1. If a manufacturer's equipment does not meet the physical dimension, clearances, weight, power, or controls limitations of the project, a change order proposal may be submitted for the Owner's and Engineer's consideration. Refer to substitution sections of

equipment specifications for substitution proposals. Proposals for equipment that does not meet the construction, materials, and performance requirements will not be accepted. The proposal shall include all changes, including other trades, required and a reduction in cost to accept the non-conforming equipment. The base bid shall include equipment that fully meets the design requirements at no additional cost.

## PART 2 - PRODUCTS

## PART 3 - EXECUTION

### 3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications for electrical rough-in requirements.

### 3.2 ELECTRICAL INSTALLATIONS

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

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
13. Contract documents were prepared based on all work being performed de-energized; unless otherwise noted. Contractor shall be responsible for coordinating with the Owner and Utilities to ensure that existing equipment is de-energized prior to work.

## 3.3 CORE-DRILLING, CUTTING AND PATCHING

A. General: Perform core-drilling, cutting and patching in accordance with the following requirements:
   1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
      a. Remove and replace defective Work.
      b. Remove and replace Work not conforming to requirements of the Contract Documents.
      c. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.
   2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
   3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
   4. Protection of Installed Work: During cutting and patching operations, protect adjacent installations. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
   5. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
   6. Inspect existing slabs prior to core-drilling for concealed, embedded or below floor existing systems including structural members. The Contractor is responsible for coordinating new work and replacing damage caused by his new work.

## 3.4 TESTING

A. Coordinate with the Owner any testing specified to be conducted after final acceptance.

## 3.5 INSPECTIONS

A. Authority Having Jurisdiction: Notify and schedule all inspections, with a minimum of 10 days notice in writing prior, to the State Construction Office. Schedule electrical inspections with SCO state electrical inspector for Monday through Friday.

END OF SECTION 260100

# SECTION 260500 - BASIC ELECTRICAL MATERIALS AND METHODS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following:

1. Electrical Equipment Installation.
2. Sleeves and sleeve seals for raceway and cable.
3. Firestopping.
4. Concrete equipment bases.
5. Touchup painting.

### 1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a third-party testing agency amongst those accredited by the NCBCC (North Carolina Building Code Council) to label electrical and mechanical equipment.

B. Comply with NFPA 70.

C. Electrical equipment shall be new and manufactured within the last 12 months unless otherwise noted and approved by the engineer.

### 1.4 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in rooms.

C. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.

2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces.

## PART 2 - PRODUCTS

### 2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

### 2.2 LINK SEALS

A. Hydrostatic Modular Pipe Seals: Rubber linkages.

1. Use a mechanical seal, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall opening.

### 2.3 CONCRETE BASES

A. Concrete Forms and Reinforcement Materials: As specified in Division 03 Section "Cast-in-Place Concrete."

B. Concrete: 3000-psi (20.7-MPa), 28-day compressive strength as specified in Division 03 Section "Cast-in-Place Concrete."

### 2.4 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

## PART 3 - EXECUTION

## 3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations. Provide any additional supporting means not provided by manufacturer to install equipment.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

## 3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Sleeves for power raceway and cables: Steel, cut sleeves to length for mounting flush with both surfaces of walls.

F. Sleeves for telecommunication cables: Rigid galvanized steel conduit, extend sleeves 2” on each side of wall. Provide plastic bushing on each end.

G. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.

H. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and raceway or cable, unless indicated otherwise.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

## 3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

## 3.4 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

## 3.5 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

## 3.6 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 09 Section “Interior Painting” and Division 09 Section “Exterior Painting”

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.7 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Final Acceptance.

END OF SECTION 260510

# SECTION 260519 - CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

### 1.3 SUBMITTALS

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

B. Field quality-control test reports: Submit all cable tests reports to Engineer ten days prior to Final Inspection.

### 1.4 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS AND CABLES

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

1. American Insulated Wire Corp.; a Leviton Company.
2. General Cable Corporation.
3. Southwire Company.

B. Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.

2.2 CONNECTORS AND SPLICES

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

1. Thomas & Betts Corporation.
2. Ideal Industries, Inc.
3. 3M; Electrical Products Division.
4. Burndy, Inc.

B. Description: Listed, factory-fabricated terminals, taps and splices of size, ampacity rating, material, type, and class for application and service indicated. Refer to gear sections for gear terminations. Splices in solid conductors shall be made using Ideal TwisterPro, 3M Performance Plus, or T&B Marrette Winged pressure type wire connectors, permanent crimp connectors are not acceptable.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Minimum Size: No. 12 AWG for power and lighting circuits.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN-THWN or XHHW, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN or XHHW, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN or XHHW, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN or XHHW, single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN or XHHW, single conductors in raceway.

G. Fire Alarm Circuits: See Section “Fire Alarm”, in raceway.

H. Class 1 Control Circuits: Type THHN-THWN or XHHW, in raceway.

I. Class 2 Control Circuits: Type THHN-THWN or XHHW, single conductors in raceway.

## 3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Voltage Drop: Conductor size shall be increased to account for voltage drop as follows:

1. Where the conductor length from the panel to the first outlet on a 277V circuit exceeds 125 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG.
2. Where the conductor length from the panel to the first outlet on a 120V circuit exceeds 50 feet, the branch circuit conductors from the panel to the first outlet shall not be smaller than #10 AWG. Increase an additional wire size for every additional 50’ to first outlet.
3. Proportionally increase size of equipment ground conductors wherever ungrounded conductor sizes are increased for voltage drop.

F. Dedicated Neutrals: Provide dedicated neutral for all single-pole branch circuits, unless otherwise noted on plans. All neutrals shall be uniquely identified at splices or taps to correspond with their ungrounded circuit conductors.

G. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

H. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems." Factory apply color the entire length of all conductors. Neutral conductors shall include tracer thread color-matched to phase conductor color.

## 3.4 CONNECTIONS

A. Keep conductor splices to a minimum. No feeders shall be spliced. No splicing shall be made except within outlet or junction boxes, troughs, or gutters.

B. 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.

C. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Splices shall be made using with pre-insulated spring/coil connectors (wire nuts), insulated barrel mechanical lugs, or box-mounted insulated terminal strips.
2. Push-in type, permanent crimp-on type, and split-bolt type are prohibited.
3. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Tests and Inspections: After installing conductors and cables and before electrical circuitry has been energized, test conductors for compliance with following requirements.

1. Physical Inspection and Testing

a. Verify cable ratings and data correspond to drawings and specifications.
b. Verify electrical connections are made to provide the electrical system described in the drawings and specifications.
c. Confirm bolted electrical connections are low impedance using one of the following means:

1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
2) Inspect the bolted connection and verify that it is at the manufacturer’s rated torque using a calibrated torque wrench.

d. A thermographic test of the distribution feeders. Conductor connection points shall be visible during the test. All equipment should be energized and loaded during test. Thermographic images of any connections that fail the test must be submitted with a description of the failure including the probable cause of the failure. A thermographic test shall be performed, but not limited to, the following areas.
1) Feeders rated for 100A or more.
e. Inspect cable connectors to verify they are correctly installed.
f. Verify all cables are identified and arranged according to the drawings and specifications.
g. Verify that all cable jackets and insulation are in good condition and did not sustain damage during installation.

2. Per State Construction Office Electrical Guidelines and Policies perform the following feeder insulation:

   a. All feeder current carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. This shall be performed with a 500 volt megger. The procedures listed below shall be followed:
      1) Minimum readings shall be 1,000,000Ω or more for #6 AWG wire and smaller and 250,000Ω or more for #4 AWG or larger between conductors and between conductor and the grounding conductor.
      2) After all fixtures, devices, and equipment are installed and all connections completed to each panel, the contractor shall disconnect the neutral feeder conductor from the neutral bar and take a megger reading between the neutral bar and the grounded enclosure. If this reading is less than 250,000 ohms, the contractor shall disconnect the branch circuit neutral wires from this neutral bar. The contractor shall then test each one separately to the panel and until the low readings are found. The contractor shall correct troubles, reconnect and retest until at least 250,000 ohms from the neutral bar to the grounded panel can be achieved with only the neutral feeder disconnected.
      3) At Final Inspection, the contractor shall furnish a megger and show the Engineers and State Construction Office representatives that the panels comply with the above requirements. Contractor shall also furnish a hook-on type ammeter and voltmeter to take current and voltage readings as directed by the representatives.
   b. Copy of all testing reports shall be sent to the State Construction Office, Engineer of Record, and to the Owner.

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

E. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

# SECTION 260526 - GROUNDING AND BONDING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

### 1.3 SUBMITTALS

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

B. Field quality-control test reports.

### 1.4 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Cable: stranded conductor sized per NEC 250 requirements.
4. Bonding Conductor: stranded conductor sized per NEC 250 requirements.
5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; sized per NEC 250 requirements.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 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.
3. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. The raceway shall not be relied on for ground continuity.

B. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide a No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each telecom service location, terminal cabinet, wiring closet, and central equipment location.

1. Cabinets, Racks, and Ladder Tray: Extend minimum #10 grounding conductor from equipment to TGB.
2. All telecommunication grounding shall be performed in compliance with TIA/EIA 607 Standard – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

## 3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 6 inches (50 mm) below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. Use exothermic welds for all below-grade connections.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Provide exothermic-welded connection to building structural steel.
4. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. Grounding Bushings and Jumpers: Boxes provided with concentric, eccentric or over-sized knockouts shall be provided with bonding bushings and jumpers lugged to box.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter and Backflow Preventer Piping: Use braided-type bonding jumpers to electrically bypass water meters and backflow preventers where located inside the building. Connect to pipe with a bolted connector.

F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

## 3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing

1. Inspect grounding system to verify that it complies with the requirements in the drawings and specifications, as well as, NFPA 70 *National Electric Code Article 250*.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards. All portions of the grounding system shall be free of corrosion.
3. Confirm bolted electrical connections are provided with low impedance using one of the following means:

   a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
   b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench.

4. Verify that adequate anchorage is in place for the grounding system.

D. Electrical Inspection and Testing

1. Conduct tests for fall of potential as defined by ANSI/IEEE 81 on the grounding system.
2. Determine the resistance to ground throughout grounding system including equipment frames, systems neutral, and equipment grounding bars. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform ground resistance in all of, but not limited to, the areas listed below:

   a. 25 ohms, per NC SCO Electrical Guidelines.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

1. Retest required to show compliance with above value.

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

G. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 260526

# SECTION 260529 - HANGERS AND SUPPORTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

### 1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

### 1.4 SUBMITTALS

A. Product Data: For anchors, supports, and slotted channel/strut systems.

### 1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

### 1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, two-hole conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps as described in NECA 1 and NECA 101.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Powder-Driven Threaded Studs: Heat-treated steel for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Toggle Bolts: All steel springhead type.
4. Hanger Rods: Threaded steel.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: Comply with MFMA-4, factory-fabricated components for field assembly; 16-gage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.3 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.
2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch-diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing. Spring steel fasteners are not permitted for use where exposed.
6. Support raceways installed on interior of exterior building walls a minimum of ¼ inch from wall surface using “clamp-back” struts.
7. Space supports for raceways in accordance with Table I of this section. Space supports for raceway types not covered by the above in accordance with NEC.
8. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals. Spring steel fasteners are not permitted for use in vertical runs. Support individual vertical runs using two-hole straps. Support parallel runs of vertical raceway together on channel using bolted clamps.

D. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

E. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.

F. Support for Fixtures in or on Grid-Type Suspended Ceilings refer to “Lighting” section, if none, then as follows: Use grid for support.

1. Fixtures within Ceiling Grid: Where a recessed fluorescent, high intensity, or downlight fixture replaces a section or part of a ceiling tile, the fixture shall be supported at the two (2) opposite ends to the building steel/concrete frame or floor decking. Supports shall be provided with the same type of wire as used to support the lay-in ceiling track. Attach the luminaire to the main runners of the lay-in ceiling track at all four (4) corners using sheet metal screws. For fire rated suspended ceiling, luminaire shall be supported to the Building Structure as per the Ceiling Design Criteria, luminaire shall then be screwed to the man runners of the suspended ceiling track at all four (4) corners using sheet metal screws.
2. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning between ceiling tees in addition to wires from building structure per above. Channel support shall be attached to ceiling grid using sheet metal screws.

G. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

H. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

3.2 TABLE I: SPACING FOR RACEWAY SUPPORTS

HORIZONTAL RUNS

| Raceway Size (Inches) | No. of Conductors in Run | Location | RMC & IMC (1) | EMT (1) | OFR (1) |
|---|---|---|---|---|---|
| 1/2,3/4 | 1 or 2 | Flat ceiling or wall. | 5 | 5 | 5 |
| 1/2,3/4 | 1 or 2 | Where it is difficult to provide supports except at intervals fixed by the building construction. | 7 | 7 | 5 |
| 1/2,3/4 | 3 or more | Any location. | 7 | 7 | ... |
| 1/2-1 | 3 or more | Any location. | | | |
| 1 & larger | 1 or 2 | Flat ceiling or wall. | 6 | 6 | ... |
| 1 & larger | 1 or 2 | Where it is difficult to provide supports except at intervals fixed by the building construction. | 10 | 10 | 5 |
| 1 & larger | 3 or more | Any location. | 10 | 10 | ... |
| Any | .... | Concealed. | 10 | 10 | ... |

VERTICAL RUNS

| Raceway Size (Inches) | No. of Conductors in Run | Location | RMC & IMC (1,2) | EMT (1) | OFR (1) |
|---|---|---|---|---|---|
| 1/2,3/4 | .... | Exposed. | 7 | 7 | ... |
| 1,1-1/4 | .... | Exposed. | 8 | 8 | ... |
| 1-1/2 and larger | .... | Exposed. | 10 | 10 | ... |
| Up to 2 | .... | Shaftway. | 14 | 10 | ... |
| 2-1/2 | .... | Shaftway. | 16 | 10 | ... |
| 3 & larger | .... | Shaftway. | 20 | 10 | ... |
| Any | .... | Concealed. | 10 | 10 | 5 |

NOTES:

(1) Support spacing listed in feet. Maximum spacing of supports 10 feet.
(2) Maximum spacings for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.

Abbreviations: EMT Electrical metallic tubing.
IMC Intermediate metallic conduit.
RMC Rigid metallic conduit.
OFR Optical Fiber Raceway.

END OF SECTION 260529

# SECTION 260533 - RACEWAY AND BOXES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes interior and exterior raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

### 1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

E. RNC: Rigid nonmetallic conduit.

F. RSC: Rigid steel conduit.

### 1.4 SUBMITTALS

A. Product Data: For raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

### 1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Allied Tube & Conduit; a Tyco International Ltd. Co.
   2. O-Z Gedney; a unit of General Signal.
   3. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
   1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
   2. Fittings for EMT: Plated-steel hexagonal compression type. Cast, pot metal, set-screw, or crimp type fittings are not acceptable.
      a. Couplings shall be “concrete tight” where concealed in masonry.
      b. Box connectors shall be insulated throat type.

G. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. AFC Cable Systems, Inc.
   2. Arnco Corporation.
   3. Lamson & Sessions; Carlon Electrical Products.
   4. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Arnco Corporation.
   2. Endot Industries Inc.
   3. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   3. Hoffman.
   4. RACO; a Hubbell Company.
   5. Thomas & Betts Corporation.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

E. Cabinets:
   1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
   1. Exposed Conduit: Rigid steel conduit.
   2. Concealed Conduit, Aboveground: Rigid steel conduit.
   3. Underground Conduit & Duct:
      a. Feeders: RNC, Type EPC-40-PVC, concrete encased.
      b. Branch Circuit: RNC, Type EPC-40-PVC, direct buried.
      c. Telecommunications: RNC, Type EPC-40-PVC, concrete encased.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Physical Damage: Rigid steel conduit.
   a. Exposed conduit routed vertically and horizontally below 8’ above finished floor in mechanical, electrical, and telecom rooms is considered subject to physical damage.
   b. Exposed conduit routed vertically up through floor slabs shall be considered subject to physical damage until it reaches 8’ above finished floor or enters a box, cabinet, or enclosure.
   c. Exposed conduit routed down vertically from above 8’ which enters boxes, cabinets, or enclosures mounted 48” to top above finished floor or higher is not considered exposed and subject to physical damage and EMT may be used.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: Rigid steel conduit.
6. Raceways for Optical Fiber or Communications Cable: Plenum-type, optical fiber/communications cable raceway.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
8. Raceway Color Coding: Apply color coding to both concealed raceway in all locations and exposed raceway in non-finished areas.
   a. Fire Alarm Raceway: EMT raceway containing fire alarm wiring shall have a factory applied red color finish.
   b. Telecom & A/V Raceway: EMT raceway containing telecom and A/V raceway wiring shall have a factory applied orange color finish.
   c. HVAC Controls Raceway: EMT raceway containing HVAC controls wiring shall have a factory applied yellow finish.
   d. 277/480V Feeder/Branch Circuit Raceway: EMT raceway containing 277/480V wiring shall have a factory applied black finish.
   e. 120/208V Feeder/Branch Circuit Raceway: EMT raceway containing 120/208V wiring shall have a factory applied blue finish.
   f. Emergency & Stand-by Feeder/Branch Circuit Raceway: EMT raceway containing emergency and stand-by wiring shall have a factory applied green finish.
   g. Rigid steel conduit used for the above systems shall be field painted to match corresponding EMT Finish.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

## 3.2 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Minimum Raceway Size:
   1. Interior: 3/4-inch trade size.
   2. Exterior, below grade: 1-inch trade size.

C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

D. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Complete raceway installation before starting conductor installation.

G. Support raceways as specified in Division 26 Section "Supporting Devices."

H. Use temporary closures to prevent foreign matter from entering raceways.

I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

M. Raceways Embedded in Concrete Slabs: Raceway shall not be installed embedded within floor and roof slabs, except where connecting to floor boxes. Install in middle third of slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.
   1. All raceway embedded in slabs shall be rigid galvanized steel conduit.
   2. Raceway shall extend a maximum of 24” from floor box before offsetting beneath slab. Raceway shall extend 12” from penetration of floor slab before transitioning back to electrical metallic tubing.
   3. Space raceways laterally to prevent voids in concrete.
   4. Run conduit parallel to or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   5. Roofing slab: Raceway shall not be embedded in roofing slabs.
   6. Raceway installed in vertical concrete wall shall be rigid galvanized steel conduit and comply with requirements for installation in slabs.

N. Raceways Installed in Load Bearing Masonry: Raceways installed in load bearing masonry shall be either rigid galvanized steel conduit or coated EMT specifically rated and listed for installation in concrete.

O. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
   1. Run parallel or banked raceways together, on common supports where practical.

2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

P. Join raceways with fittings designed and approved for the purpose and make joints tight.
1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.

Q. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.
1.
2. Where concentric, eccentric, or over-sized knock outs are encountered, a grounding-type insulated bushing shall be provided.

R. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

S. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.

T. Telecommunications Stub-ups & Sleeves: Provide plastic bushings on all conduit stub-ups and sleeves.

U. Telecommunications Raceways, 4-Inch Trade Size (DN53) and Smaller: In addition to the above requirements, install raceways in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes sized per BICSI's Telecommunications Distribution Methods Manual where necessary to comply with these requirements. All bends shall be sweeping long radius manufactured elbows.
1. Type LB and similar condulet fittings are not permitted for use with any telecommunications raceways.
2. Flexible metal conduit (FMC) is not permitted for use as a telecommunications raceway.

V. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

W. Stub-up Connections: Where underground raceways are required to turn up into equipment, cabinets, etc., 3'-0' from the elbow, the elbow and stub-up shall be rigid steel. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.

X. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.

Y. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

## 3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at equipment and at building entrances through the floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose.
   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

## 3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

## 3.5 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

# SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

### 1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of all electrical equipment and system components used in identification signs and labels. Schedule shall depict preliminary printouts of proposed equipment labels for review prior to order.

### 1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

## PART 2 - PRODUCTS

### 2.1 RACEWAY AND CABLE LABELS

A. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

B. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

1. Not less than 6 inches wide by 4 mils thick (152 mm wide by 0.102 mm thick).
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend indicating type of underground line.

C. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

D. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

## 2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
   1. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting.

E. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

## 2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength: 50 lb (22.3 kg) minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   4. Color: According to color-coding.

B. Paint: Formulated for the type of surface and intended use.
   1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
   2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
   3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
   4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project. For minor renovation projects, match the existing building color scheme.
   1. General 120/208V Equipment including Optional and Legally Required Standby: Blue label with white core.
   2. General 277/480V Equipment including Optional and Legally Required Standby: Black label with white core.
   3. Fire Alarm Equipment: Red label with white core.
   4. Data Systems: Brown label with white core.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Install painted identification according to manufacturer's written instructions and as follows:
   1. Clean surfaces of dust, loose material, and oily films before painting.
   2. Prime surfaces using type of primer specified for surface.
   3. Apply one intermediate and one finish coat of enamel.

F. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below. Banding of colored conduit is not required.
   1. Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
   2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas. Also provide color banding at outlet box stub-ups.
   3. Apply the following band colors to the systems and junction box covers as per listed below:
      a. Fire Alarm System: Red.
      b. Telecom (Intercom, Data, Video) Systems: Blue.
   4. Apply raceway band and junction box cover colors consistent with colors applied to equipment as per the “Lettering, Colors and Graphics” section specified above.
   5. Spare raceway for future use shall be identified as such and shall indicate where raceway originates and terminates on each end.

G. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

H. Circuit Identification Labels on Outlet Boxes, Junction Boxes and Pull Boxes: Install labels externally.
   1. Outlet boxes (receptacles and switches) and exposed junction boxes: Pressure-sensitive, self-adhesive plastic label on faceplate. Use clear label with black letters.
   2. Concealed junction and pull boxes: Neat handwritten label using permanent black marker.
   3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
   4. Future Use Circuits: Circuits for future use shall be identified as such and list panel and circuit number of source.

I. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.
   1. Color-code 208/120-V system as follows:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
      d. Neutral: White.
      e. Ground: Green.
   2. Color-code 480/277-V system as follows:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
      e. Ground: Green.
   3. Factory apply color the entire length of all conductors. Neutral conductors shall have special tracer color thread.

J. Apply identification to conductors as follows:
   1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
   2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
   3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

K. Identify Electrical Workspace as follows:
   1. In electrical rooms, outline on floor the front and rear accessible workspace clearances around equipment with yellow paint or permanent tape.

L. Apply warning, caution, and instruction signs as follows:
   1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
   2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

M. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. Locate label on exterior of any enclosure. This includes power, lighting, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide three lines of text with 1/4-inch high lettering on 1-1/2-inch high label; where four lines of text are required, use labels 2 inches high. Use surface and core colors as listed in Part 2 above. Provide labels for all electrical equipment listed below. In general, all labels shall include riser diagram ID, amperage, voltage, number of phases/poles, and equipment served from (source). Provide additional information as listed below:

1. Panelboards: MCB/MLO.
   a. Label source panel and its location.
   b. Label maximum fault current calculation and date performed on panels.
2. Disconnect switches: equipment served by.
   a. Provide label for all disconnects provide by Division 23, 24 or 26.
3. Enclosed circuit breakers: equipment served by.
   a. Provide label for all disconnects provide by Division 23, 24 or 26.
4. Contactors & Relay Panels.
   a. Label area or lighting served by.
5. Transformers:
   a. Label downstream panel served by.
6. Fire Alarm Control Panel and auxiliary power supplies and enclosures.
7. Outside Feeder Disconnects: Provide placard at disconnects indicating maximum fault current and date of calculation per NEC Article 110.24. Maximum fault current shall be coordinated with utility and placard installed prior to energization
   a. Where a building or structure has feeders, branch circuits supplying it, a permanent plaque or directory shall be installed at each feeder and branch circuit disconnect location denoting 1) all other feeders or branch circuits supplying that building or structure or passing through that building or structure and 2) the area served by each disconnect, and 3) the location of the source if not within sight.

END OF SECTION 260553

# SECTION 260571 – POWER SYSTEM STUDY

## 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 a computer-based power system one-line model, fault current analysis, overrcurrent setting/trip coordination, and arc flash study including gathering power system field data and submitting study reports to determine:
   1. Minimum interrupting capacity of circuit protective devices.
   2. Overcurrent protective devices and to determine overcurrent protective device settings for selective coordination tripping.
   3. Arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.
   4. Labeling of effected equipment.

B. The Contractor shall be responsible to coordinate to 0.1 seconds per NCBC all overcurrent protective devices within the scope of work, unless indicated otherwise.

C. The extent of the electrical power system to be studied is indicated on Drawings; unless otherwise noted, scope shall include all new protective devices and equipment, and in renovations and additions their next higher and lower existing devices and equipment.

### 1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Pre-Installation Submittal: Included with major distribution equipment submittal, shall be a preliminary study report prepared using actual submitted equipment and overcurrent protective devices.

1. Refer to “Report Content” articles below for submittal requirements.
2. Feeder lengths shall be based on actual Contractor take-offs, using typical minimum lengths is not acceptable.
3. Preliminary submittal shall include copy of proposed flash warning labels.

B. Post-Installation Submittal: Up to 30 days prior to Substantial Completion, Contractor shall submit an updated report.

1. Updated report shall include actual equipment installed and measured feeder lengths.
2. Copy of updated proposed flash warning labels shall also be included.
3. After Engineer approval of post-installation report Contractor shall generate and install adhesive flash warning labels.
4. All study and equipment evaluation reports; signed, dated, and sealed by a qualified professional engineer study specialist.

1.5 CLOSEOUT SUBMITTALS

A. A copy of the final corrected Study shall be included with the Owner’s Operations & Maintenance Manuals.

1.6 QUALITY ASSURANCE

A. Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

B. Computer Software:

1. SKM Power Tools
2. ESA Easy Power

C. Comply with IEEE 242, 399, 551, 1584, and NFPA 70E.

PART 2 - POWER SYSTEM STUDY PROCEDURES

2.1 EXAMINATION

A. This article lists data needed to conduct the study. Contractor is responsible for gathering all data not included in the one-line drawings that are part of the Contract Documents.

B. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect and Engineer.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
4. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

2.2 INPUT DATA

A. Gather and tabulate the following input data to support the power system study. Comply with recommendations in IEEE 551, IEEE 1584, and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Voltage level at each bus.
5. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
7. Motor horsepower and NEMA MG 1 code letter designation.
8. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
9. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Ratings, types, and settings of utility company's overcurrent protective devices.
   e. Special overcurrent protective device settings or types stipulated by utility company.
   f. Time-current-characteristic curves of devices indicated to be coordinated.

g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
h. Panelboards ampacity, and SCCR in amperes rms symmetrical.

## 2.3 SHORT CIRCUIT STUDY PROCEDURE

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. All equipment depicted on electrical distribution riser diagram, as well as all motors 30 horsepower and larger, shall be included in system model. Fault contribution to system shall be based on available fault current on secondary of service transformer as provided by utility company, or other fault current source(s), whichever is largest.

F. Begin short-circuit current analysis at the first upstream existing overcurrent protective device, extending down to all the new work overcurrent protective devices.

G. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

H. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators 30 horsepower and larger, and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
1. Distribution & branch circuit panelboards.
2. Disconnect switches.

J. Provide permanent name plates showing date of calculation and three-phase bolted fault short-circuit study values at all service disconnects, switchgear, switchboards, panelboards and motor control centers in the scope of work and where indicated.

K. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

## 2.4 OVERCURRENT PROTECTIVE DEVICE STUDY PROCEDURE

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

E. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

G. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

H. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
1. Distribution & branch circuit panelboards.

J. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of panelboard bus bars to withstand short-circuit stresses.

2.5 ARC FLASH STUDY PROCEDURES

A. Comply with IEEE 1584, and NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Section 2.3
2. Protective Device Coordination Study Section 2.4

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include low-voltage equipment locations, except equipment rated 240-V ac or less with an available short-circuit current less than 2 kA as determined by the short-circuit study.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

PART 3 – POWER SYSTEM STUDY DELIVERABLES

3.1 REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings depicted on the electrical distribution riser diagram.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor designations and kVA ratings.
5. Panelboard designations.

D. The overcurrent/ground fault setting coordination shall create a set of time-current curves depicting successive breakers and fuses for each unique distribution system branch. Coordination shall be to 0.06 seconds, unless the AHJ requires 0.01 seconds.

E. Comments and recommendations for system improvements, where study results fail to meet design intent, specified requirements or industry standards.

F. Study Input Data: As described in Section 2.2.

G. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

H. Short-Circuit Study Output:

1. The fault current analysis portion of the report shall include a print out from the software listing the available three-phase, Line-Line, and Line-Ground fault current at each piece of equipment and highlight exceeded equipment ratings.
2. Low-Voltage Fault Report: Three-phase, Line-Line, and Line-Ground fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. Equivalent impedance.

I. Protective Device Coordination Study Ouput:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
   a. Circuit Breakers:
      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.
   b. Fuses: Show current rating, voltage, and class.

J. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   b. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   c. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   d. Cables and conductors damage curves.
   e. Ground-fault protective devices.
   f. Motor-starting characteristics and motor damage points.
   g. The largest feeder circuit breaker in each panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

K. Arc-Flash Study Output:

1. Incident Energy and Flash Protection Boundary Calculations:
   a. Arcing fault magnitude.
   b. Protective device clearing time.
   c. Duration of arc.
   d. Arc-flash boundary.
   e. Working distance.
   f. Incident energy.
2. Summary narrative of recommendations including overcurrent trip setting adjustments for arc-flash energy reduction to Owner’s standard protection ratings.

## 3.2 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis. Adhesive must be suitable for the environment.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis, and comply with NFPA 70E:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. PPE required.
6. Incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

D. Apply one arc-flash label for 600-V ac, 480-V ac, 240-V ac and applicable 208-V ac panelboards and disconnects and for each of the following locations, or as required by Owner's standard:

1. Industrial control panel.
2. Lighting inverter.
3. Transformer.
4. Motor starter or VFD.

E. Install the arc-fault warning labels under the direct supervision and control of the Study Specialist.

## 3.3 FIELD ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit, protective device coordination, and arc flash studies.

END OF SECTION 260571

# SECTION 26 22 00 - DRY-TYPE TRANSFORMERS

## 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 power distribution control dry-type transformers rated 600 V and less.

### 1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

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. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

### 1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

### 1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. General Electric Company.
3. Siemens Energy & Automation, Inc.
4. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Windings: Aluminum.

D. Enclosure: Ventilated, NEMA 250, Type 2.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

F. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

G. Minimum Impedance:

1. 75kVA and less: Minimum 4.0% impedance. Resulting maximum inrush 12x rated primary current.
2. 112.5kVA and greater: Minimum 4.5% impedance. Resulting maximum inrush 12x rated primary current.

H. Energy Efficiency for Transformers Rated 15 kVA and Larger:
1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

I. Wall Brackets: Manufacturer's standard brackets.

## 2.4 FINISHES

A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

## 2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

## 2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

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

## 3.2 INSTALLATION

A. Comply with safety requirements of IEEE C2.

B. Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

C. Install floor-mounted transformers on concrete base, 4-inch (100-mm) nominal thickness extending 2” beyond enclosure with chamfered edge. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

D. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

E. Grounding: Provide singe, multi-barrel (conductor) mechanical grounding lug for all grounding and bonding connections in transformer.

## 3.3 EQUIPMENT TESTING

A. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

B. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
3. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
4. Verify that all packing materials have been removed and the equipment has been cleaned.
5. Confirm bolted electrical connections are provided with high impedance using one of the following means:

   a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
   b. Inspect the bolted connection and verify that it is at the manufacturer’s rated torque using a calibrated torque wrench. If manufacturer’s data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

C. Electrical Inspection and Testing

1. Test the Insulation resistance from winding to winding and from winding to ground. Compare the gathered resistance data with manufacturer’s data if manufacturer’s data is not available compare against Table 100.5 in the ANSI/NETA ATS-2009. Determine the polarization index and verify that it is not less than 1.
2. Measure the secondary voltage from phase to phase and from phase to ground to verify it meets the requirements of the drawings and specifications as well as the equipment rating. Measurements should be taken after the transformer has been energized but prior to transformer loading.

D. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

## 3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

## 3.5 FIELD QUALITY CONTROL

A. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

B. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer’s standards.
3. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
4. Verify that all packing materials have been removed and the equipment has been cleaned.
5. Confirm bolted electrical connections are provided with high impedance using one of the following means:

   a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
   b. Inspect the bolted connection and verify that it is at the manufacturer’s rated torque using a calibrated torque wrench. If manufacturer’s data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

6. Inspect tap positions and verify they meet the requirements of the drawings and specifications. Tap connections should not be changed unless otherwise specified.

C. Electrical Inspection and Testing

1. Test the Insulation resistance from winding to winding and from winding to ground. Compare the gathered resistance data with manufacturer’s data if manufacturer’s data is not available compare against Table 100.5 in the ANSI/NETA ATS-2009. Determine the polarization index and verify that it is not less than 1.
2. Measure the secondary voltage from phase to phase and from phase to ground to verify it meets the requirements of the drawings and specifications as well as the equipment rating. Measurements should be taken after the transformer has been energized but prior to transformer loading.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Remove paint splatters and other spots, dirt, and debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

END OF SECTION 26200

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.

B. Refer to Section 260571 "Power System Study" for overcurrent protective device coordination and submittal requirements.

1.2 SUMMARY

A. Section Includes:
1. Lighting and appliance branch-circuit panelboards.

1.3 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Room names and numbers shall match the final signage at the site. Submit final versions prior to installation in panelboard.

E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

## 1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NEMA PB 1.

## 1.6 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## 1.7 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. ABB, formerly General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets as noted on schedules.

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
2. Front Cover: For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trim shall cover all live parts and shall have no exposed hardware.
   a. Flush Mounted Panelboards: Trim shall extend beyond box at least 1” in all dimensions.
   b. All panelboards shall have hinged trim along one vertical side of the enclosure hinged to box. Continuous piano hinge. Provide standard door with front trim (door-in-door) enabling full access to the branch wiring terminations along both sides of the enclosure.
3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
4. Finishes:

   a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
   b. Back Boxes: Galvanized steel.

5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
6. Main Overcurrent Protective Devices: Molded-case circuit breakers.

   a. Center Mounted Main: Branch mounted main breakers are not allowed.

7. Branch Overcurrent Protective Devices: Molded-case circuit breakers.

   a. Center mounted branch devices and sub-feed branch devices are not allowed.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity

1. Neutral Bus: Neutral bus rated 100 percent of phase bus.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box. For branch circuit panelboards provide a minimum of 21 terminals.

D. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

E. Feed-through Lugs: Not acceptable.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices. Future devices indicated as "SPACE" on drawings.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rating of equipment is not acceptable.

## 2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker, unless otherwise noted on drawings.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

## 2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with full interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Field-adjustable instantaneous trip setting for circuit-breaker trip ampere ratings 100 A to 225A.
2. Electronic Trip Circuit Breakers:

   a. Lighting and Appliance Branch Panelboards: Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip and individually field-adjustable long-time, short-time and instantaneous trip pickup settings. Provide for circuit-breaker trip ampere ratings 250A and larger. Provide trip unit internal power supply for 0-100% rating current indication.
   b. Distribution Panelboards: Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip and individually field-adjustable long-time trip, short time trip, and instantaneous trip pickup settings. . Provide for circuit-breaker trip ampere ratings 250A and larger. Provide trip unit internal power supply for 0-100% rating current indication.
3. Molded-Case Circuit-Breaker (MCCB) Features:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

4. Molded-Case Circuit-Breaker (MCCB) Accessories (where indicated):

a. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install filler plates in unused spaces.

F. Stub eight 3/4-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 3/4-inch empty conduits into raised floor space or below slab not on grade.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

H. Comply with NECA 1.

I. .

## 3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

E. Switchboards, switchgear, and panelboards shall have a short-circuit current rating not less than the available current. In other than one and two-family dwelling units, the available fault current and the date the calculation was performed shall be field marked on the enclosure at the point of supply. The marking shall comply with 110.21(B)(3).

## 3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Testing Technician

   a. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

2. Physical inspection and Testing

   a. Verify equipment rating correspond to drawings and specifications.
   b. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
   c. Verify equipment is properly secured and aligned with the required clearances as specified in the drawings and specifications. Assure that the equipment is properly grounded.
   d. Verify that all packing materials have been removed and the equipment has been cleaned.
   e. Confirm all breaker sizes, quantities, and configurations correspond to the drawings and specifications.
   f. Confirm bolted and mechanical lug electrical connections are low impedance using one of the following means:
      1) Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.

2) Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

3. Electrical Inspection and Testing

a. Test each bus section for insulation resistance for one minute on phase to phase and phase to ground connections. Verify the test results comply with manufacturer's documentation or the requirements established in Table 100.1 of the ANSI/NETA ATS-2009.
b. Verify all meters functionality and accuracy after testing and calibrating all inputs.
c. Verify instrument transformers meet all the requirements of the drawings and specifications.
1) Test transformer wiring integrity and proper transformer operation.
2) Verify transformer output voltage is at the specified level.

4. Test Reports: Prepare a written report to record the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.5 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges. Unless otherwise noted, trip settings shall mimic trip characteristics for thermal magnetic circuit-breakers of similar trip rating.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes receptacles, connectors, and finish plates.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

C. SPD: Surge Protection Device.

1.4 SUBMITTALS

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

B. Field quality-control test reports.

C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

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

C. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Wiring Devices:
      a. Hubbell, Inc.; Wiring Devices Div.
      b. Leviton Manufacturing Co., Inc.
      c. Pass & Seymour/Legrand; Wiring Devices Div.

### 2.2 STRAIGHT BLADE RECEPTACLES

A. General Purpose Receptacles: Heavy-Duty grade shall be Federal Grade per SCO Guidelines, rated 20A minimum. Comply with UL498.
   1. NEMA 5-20R (standard #WD1.101968).
   2. Arranged for back and side wiring.
   3. Grounding type. Separate single or double grounding terminals with screw lugs and a direct, green insulated conductor connector to system ground. Screw shall be green and hex-headed. Self-grounding type are not acceptable.
   4. Weather-resistant receptacles shall be marked with WR on face.
   5. Listed by an approved third party agency.

B. GFCI Receptacles: Non feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle arranged to protect connected downstream receptacles on same circuit. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter. Comply with UL 498 and UL 943, Class A.

### 2.3 SWITCHES

A. General Purpose Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
   1. 20A, 120/277v, AC only.
   2. Grounding type, with green hex-head grounding screw.
   3. Quiet type operating mechanism; shall not utilize mercury switches.
   4. Listed by an approved third party agency.

B. Equipment Disconnect Snap Switches: Heavy-duty, quiet type. Comply with NEMA WD1 and UL 20.
   1. 30A, 120/277v, AC only.
   2. Grounding type, with green hex-head grounding screw.
   3. Quiet type operating mechanism; shall not utilize mercury switches.
   4. Listed by an approved third party agency.

### 2.4 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.04-inch (1-mm) thick, Type 302, satin-finished stainless steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: "In Use" cast aluminum with spring-loaded lift cover capable of closing with plug assembly still engaged, and listed and labeled for use in "wet locations" and "Extra Duty".

## 2.5 FINISHES

A. Color:
   1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
1. Mount vertically except where installed over counters, back-splashes, etc. mount horizontally.
2. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Damp and Wet Locations:
1. Provide weather-resistant receptacles with weatherproof cover in damp and wet locations.
2. Provide additional weather-resistant receptacles with weatherproof cover as indicated on the plans.

G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
   a. Provide 2% quantity of spare cover plates of each type to Owner.

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 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

## 3.3 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

## 3.4 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 262726

# 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 and controllers.

### 1.3 SUBMITTALS

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

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

### 1.4 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.

### 1.5 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

### 1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than six of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

3.2 FUSE APPLICATIONS

A. Motor and Motor Controller Branch Circuits: Class RK5, UL listed, current limiting time delay, 200 kA interrupting rating.

B. Other Individual Equipment Branch Circuits: Class RK5, UL listed, non-time delay, 50 kA interrupting rating.

3.3 INSTALLATION

A. Fuses shall be selected as to provide a fully selective system.

B. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

# 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.

B. Refer to Section 260571 “Power System Study” for overcurrent protective device coordination and submittal requirements.

### 1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
1. Feeder and branch-circuit protection.
2. Motor and equipment disconnecting means.

### 1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

### 1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

C. Field quality-control reports.
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

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

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Fusible Switches:
      a. Eaton Corp.; Cutler-Hammer Products.
      b. General Electric Co.; Electrical Distribution & Control Division.
      c. Siemens Energy & Automation, Inc.
      d. Square D Co.
   2. Molded-Case Circuit Breakers:
      a. Eaton Corp.; Cutler-Hammer Products.
      b. General Electric Co.; Electrical Distribution & Control Division.
      c. Siemens Energy & Automation, Inc.
      d. Square D Co.

2.2 ENCLOSED SWITCHES

A. All Switches:
   1. Heavy Duty type with nonteasible, positive, quick make-quick break mechanisms.
   2. Handles whose positions are easily recognizable and are padlockable in either the “on” or “off” positions.

3. Defeatable door interlocks that prevent the door from opening when the operating handle is in the "on" position.

B. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.

C. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks.
   1. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

## 2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with full 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. Field adjustable instantaneous trip setting for circuit-breaker frame sizes 100 A to 225A.

B. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

## 2.4 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 4X.
   3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

## 3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

B. Testing Technician

1. The testing technicians shall be trained in all the methods of correctly and safely conducting the required test. The technician shall have regular experience conducting the required tests and they must have the knowledge to determine the serviceability of a specific piece of equipment.

C. Physical Inspection and Testing

1. Verify equipment rating correspond to drawings and specifications.
2. Inspect the physical and mechanical condition and verify that it complies with manufacturer's standards.
3. Verify equipment is properly secured and aligned as specified in the drawings and specifications.
4. Verify the equipment is clean.
5. Open and close circuit breaker to verify smooth and proper operation.
6. Confirm bolted electrical connections are low impedance using one of the following means:

   a. Measure the resistance with a low-resistance ohmmeter. Bolted electrical connection resistances shall be compared to resistances measured on similar connections. Any similar resistance values that deviate more than 50 percent should be investigated.
   b. Inspect the bolted connection and verify that it is at the manufacturer's rated torque using a calibrated torque wrench. If manufacturer's data is not available verify the torque meets the requirements of Table 100.12 in the ANSI/NETA ATS-2009.

D. Electrical Inspection and Testing

1. Test the insulation resistance on each pole. The resistance should be measured from phase to phase and phase to ground while the breaker is engaged. When the switch is not engaged the insulation resistance should be measured across each pole. For testing purposes apply a voltage as recommended by the manufacturer. If no recommendations are available from the manufacturer refer to Table 100.1 in the ANSI/NETA ATS-2009.

E. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Remove and replace units that do not pass tests and inspections and retest as specified above.

H. Retain paragraph below if tests and inspections are performed by Contractor or manufacturer's field-service representative engaged by Contractor.

I. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 262816

# SECTION 265100 - LIGHTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:
1. Lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:
1. Division 26 Section "Lighting Control Devices" for digital timer light switches.

### 1.3 DEFINITIONS

A. The term Architect refers to the Architect, Interior Designer, Lighting Designer and/or Owner's Representative individually or collectively.

B. CRI: Color-rendering index.

C. LED: Light Emitting Diodes.

### 1.4 GENERAL REQUIREMENTS

A. Provide all lighting fixtures as shown complete with all lamps, completely wired, controlled and securely attached to supports.

B. Where a catalog number and a narrative or pictorial descriptions are provided, the written description shall take precedence and prevail.

C. General Contractor shall provide electrical subcontractor with entire lighting specification and applicable drawings (including fixture illustrations and sketches); electrical subcontractor shall provide each specified manufacturer or manufacturer's representative with complete information about the fixtures they will supply.

D. Type of fixtures shall be as indicated alphanumerically and as specified.
Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:

1. Fixture performance is equal or improved;
2. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved;
3. Cost to the Owner is reduced or equal.
4. Modifications have been reviewed by the Architect and have been approved by the Architect/Engineer in writing.

1.5 SUBMITTALS

A. Product Data:

1. Bill of Materials: At the front of the product data submittal provide a matrix that lists the fixture manufacturer and model number and driver manufacturer and model number for each fixture type in schedule.
2. Light Fixtures: For each type of lighting fixture in schedule, arranged in order of fixture designation. Provide manufacturer’s published literature which includes data on features, accessories, and the following:
   a. Dimensions of fixtures.
   b. Manufacturer and type of drivers.
   c. For fixtures (non-exit) with LED light source submit the manufacturer’s IESNA LM-79 Photometric Report and IESNA LM-80 Lumen Maintenance Report.
   d. Method of emergency driver installation (integral, external, or remote).
3. Emergency Drivers: For each type of emergency driver installed in a scheduled lighting fixture, provide manufacturer’s published literature containing lumen output, time duration, battery type, driver dimensions, and mounting. Also provide wiring diagram.
4. Design Lights Consortium (DLC) listing: Provide documentation for DLC listing from the DLC website qualified products list. Documentation shall be specific to submitted model numbers. Stamp or DLC logo on fixture cut sheets is not acceptable.
5. Exit/Emergency Warranty Information: Include in submittals warranty information for emergency exit signs, emergency lighting units, and emergency ballasts installed in schedule fixtures.
   a. The entire unit shall be warranted for three years. The battery must have an additional two more years pro-rated warranty. Warranty shall start from the date of project final acceptance. Warranty shall be included in the contract document.

B. End of Project

1. Test Reports: Report of operation test for emergency lighting units, emergency ballasts, and battery-powered exit signs. See Field Quality Control paragraph below.
   a. Submit copy to State Construction Office.
2. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 1. Provide revised and updated Fixture Schedule Matrix. Include all warranty information and documentation with maintenance data.
3. Special Warranty for LED Drivers: Written warranty, executed by manufacturer agreeing to replace LED drivers that fails in materials or workmanship within 5 years from date of manufacturer, but not less than 4 years from date of Final Acceptance.
4. Special Warranty for Emergency Exit Signs, Emergency Lighting Units, and Emergency Drivers: Written warranty, executed by manufacturer agreeing to replace entire

sign/unit/driver that fails within 3 years from date of Final Acceptance. The batteries within sign/unit/driver shall be covered for an additional 2 years by a pro-rated warranty.

5. Extra Materials
   a. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Store at the site where directed.
      1) Confirm extra material quantities with Owner prior to ordering.
   b. Lamps: 1 for every 10 of each type and rating installed. Furnish at least two of each type.
   c. Drivers: 1 for every 100 of each type and rating installed. Furnish at least two of each type. Includes emergency battery drivers.
   d. Non-Serviceable Light Fixtures: Provide 1 complete fixture for every 100 of each type and rating installed. Furnish at least two of each type
   e. Furnish items above with appropriate quantity of each exposed trim, fastener, bracket and other items as required for a complete installation.

## 1.6 QUALITY ASSURANCE

A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

## 1.7 COORDINATION

A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Available Manufacturers and Products: Subject to compliance with requirements, manufacturers and respective products that may be incorporated into the Work are indicated on the drawings in Light Fixture Schedule.
   1. It is the intent of the Light Fixture Schedule to denote the Basis of Design and quality standard of product desired and not to restrict bidders to a specific brand, make, manufacturer or specific name. The manufacturers and products listed in Schedule are used only to set forth and convey to bidders the general style, type, character, and quality of product desired. However, the use of products by a manufacturer not listed in Schedule is considered a substitution. Substitution of equivalent products will be acceptable according to the following paragraph.

B. Substitution of Equivalent Products: Substitution of manufacturers and products equivalent to those listed in Light Fixture Schedule shall be submitted to the Engineer for approval through the product/shop drawing submittal review process.

C. Equivalent fixtures, poles, ballasts, and other materials and equipment shall be products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall be a standard product offering as shown on manufacturer's published printed literature for appearance, mounting, light distribution and lamping (ballast and lens options are excluded from this requirement). Cut-sheets prepared for submittal are not considered published printed literature. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same type or class of fixture are required, these items shall be products of a single manufacturer.

## 2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Fixtures shall be free of light leaks and shall be designed to provide sufficient ventilation and heat management of fixture components, including vent holes where required.

B. Outdoor fixtures shall have wire mesh corrosion resistant screens in the vent holes properly sized to prevent incursion of insects, small animals, and/or other small rodents.

C. In outdoor applications, and where the ambient falls below 50°F, all fixture components shall be rated for operation at 0°F, unless otherwise noted.

D. In adjustable fixtures, aiming and positive locking devices shall be provided so that aiming can be permanently set so that the fixture shall remain correctly positioned after service.

E. Power factor shall be greater than 90%.

F. Light fixtures shall be listed on one or more of the following websites:
1. Energy Star (www.energystar.gov)
2. Design Light Consortium (www.designlight.org)
3. International Dark-Sky Association (www.darksky.org)

G. Metal Parts: Free from burrs, sharp corners, and edges.

H. Sheet Metal Components: Steel, unless otherwise indicated.

1. Form work shall be properly fabricated so that planes will not deform. Form and support to prevent warping and sagging.
2. Free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal.
3. Intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.
4. Miters shall be in accurate alignment with abutting intersecting members.
5. Piecing of plates in individual runs in single planes and the use of spliced pieces or filler material to cover defective workmanship shall not be acceptable.

I. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit access for servicing from below without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during servicing and when secured in operating position.

J. Fasteners: Manufactured of non-magnetic stainless steel or anodized aluminum, except in indoor applications where galvanized steel shall be acceptable.

K. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated: verify values with master spec/reps/IES

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

L. Lenses:

1. Glass:
    a. Flat glass lenses shall be heat tempered borosilicate glass unless otherwise noted.
    b. Glass finishes, i.e. sandblasting, etching, polishing shall be performed as described in the fixture description.
2. Acrylic:
    a. Lenses shall be of injection molded 100% virgin acrylic (except as shown). Lenses shall be a minimum of 0.125” thick, unless greater thickness is indicated. For lenses with male pattern of pyramids or cones, specified minimum thickness refers to distance from flat surface to base of pyramids (cones), or thickness of undisturbed material. For lenses with female pattern, specified minimum thickness refers to overall thickness of material.
    b. Lenses shall fully eliminate light source images when viewed from all directions.
    c. Finishes, i.e. sandblasting, etching, polishing shall be performed as described in the fixture description.
3. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.

M. Wiring:

1. Temperature Rating – Internal to Fixture
    a. All wiring shall be code-approved for fixture wiring, and shall comply with the following temperature ratings unless fixture design or local codes require higher temperature wire.
2. Splices.
    a. Splices internal to fixture shall be made within separate splice compartments and shall utilize insulated quick disconnects.
    b. Splices to branch circuit wiring in separate junction boxes shall utilize flame retardant thermoplastic caps with fully seated helical metal spring and threaded entry.
3. No internal wiring shall be visible at normal viewing angles, i.e., above 45° from vertical. Use additional wire clamps if necessary. Anticipate increased visibility if fixtures are mounted on or recessed within a sloping surface.

4. Any fixture fed from more than one panel, i.e., for normal and night or emergency operation, shall have separate neutrals to each panel.
5. Furnish code-approved plenum-rated wiring in ceiling cavities forming air plenums.

## 2.3 SOLID STATE LIGHTING – LED LUMINAIRES, DRIVERS, AND COMPONENTS

A. General:

1. Luminaire manufacturer shall have a minimum of five (5) years' experience in the manufacture and design of LED products and systems and no less than one hundred (100) installations.
2. All LED luminaires, drivers, components, and peripheral devices are to be provided by and shall be the responsibility of a single entity. All components shall perform successfully as a complete system and shall operate as described in Light Fixture Schedule.
3. Include all components necessary for a complete installation. Compatibility of driver and LED light engine must be tested and ensured by driver manufacturer.
4. 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 5 years at start of construction of project. Acceptable LED lamp manufacturers include but are not limited to:
    a. Philips Lighting
    b. Nichia Corporation
    c. Norlux
    d. Opto Technology, Inc.
    e. eldoLED
    f. Osram Digital Systems

B. Replacement and Spares:

1. Manufacturer shall provide written guarantee of the following:
    a. Manufacturer will keep record of original bin for each LED module.

3. All parts of system shall be replaceable in field. Manufacturer shall provide written guarantee of the following:
    a. System shall carry a full manufacturer's warranty for five (5) years. Manufacturer shall be responsible for cost of labor, and cost of shipping, to replace any component of the system.
4. Products and Components – Performance
    a. LED luminaires and components shall be UL listed or have equivalent third party listing that is acceptable to the AHJ.
        1) Manufacturer shall be able to provide supporting documentation of the product meeting third party regulatory compliance.
    b. Manufacturer shall ensure that products undergo and successfully meet appropriate design and manufacturability testing including, NEMA/ANSI standards, IEC standards and UL/CE testing.
    c. LEDs shall comply with ANSI/NEMA/ANSLG C78.377-2017 – Specifications for the Chromaticity of Solid State Lighting Products. Color shall remain stable throughout the life of the lamp.

d. LEDs shall comply with IESNA LM-80 – Standards for Lumen Maintenance of LED Lighting Products.
e. White LEDs shall have a rated source life of 50,000 hours under normal operating conditions. RGB LEDs shall have a rated source life of 100,000 hours. LED "rated source life" is defined as the time when a minimum of 70% of initial lumen output remains.
f. Manufacturer shall supply in writing a range of permissible operating temperatures in which system will perform optimally.
g. For wet and damp location use, LED-based luminaires itself shall be sealed, rated, and tested for appropriate environmental conditions, not accomplished by using an additional housing or enclosure. Such protection shall have no negative impact on rated life of source or components, or if so, such reductions shall be explicitly brought to the attention of the designer.
h. 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 the most recent version of IES LM-79, based on test results from an independent Nationally Recognized Testing Laboratory.
i. Power / data supply shall have the following:
   1) Supply shall provide connections that are conduit-ready or clamp-style connections in the case of low-voltage wiring.
   2) Supply shall come with a housing that meets a minimum IP20 rating for dry location installation unless located in a damp or wet location.
   3) Supply shall be NRTL listed for Class 1 or Class 2 wiring

2.4 LED DRIVERS

A. General:
   1. Ten-year operational life while operating with a case temperature range of 0 degrees C to 62 degrees C and 90 percent non-condensing relative humidity.
   2. Electrolytic capacitors to operate at least 20 degrees C below the capacitor's maximum temperature rating when the driver is under fully-loaded conditions and case temperature is 62 degrees C.
   3. Designed and tested to withstand electrostatic discharges up to 15,000 V without impairment per IEC 801-2.
   4. Maximum inrush current of 2 amperes for 120V and 277 V drivers.
   5. Withstand up to a 4,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A.
   6. Manufactured in a facility that employ ESD reduction practices in compliance with ANSI/ESD S20.20.
   7. Inaudible in a 27 dBA ambient environment.
   8. No visible change in light output with a variation of +/- 10 percent line voltage input.
   9. Total Harmonic Distortion less than 10 percent and meet ANSI C82.11 maximum allowable THD requirements

B. Compatibility of driver and LED light engine must be tested and ensured by driver manufacturer.

## 2.5 EMERGENCY EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:
   1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
   2. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life. Maximum LED failure rate shall be 25% within a 7 year period.
   3. Emergency Operation: When normal voltage drops below 80% nominal, sign shall switch to operation from emergency battery.
   4. Testing Features: Exit sign shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. Sign shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
   5. Exit Signs shall be third party listed as emergency lighting equipment, and meet or exceed the following standards: NEC, NC Building Code, NC Energy Conservation Code, NFPA 101, and any applicable NEMA standards.

B. Integral Emergency Battery: Battery shall be sealed, maintenance-free nickel-cadmium sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with an operating range of 0°C to 60°C and contain a resealable pressure vent. Exterior signs shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.

C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

## 2.6 EMERGENCY LIGHTING UNIT

A. General Requirements: Comply with UL 924 and the following:
   1. Description: Emergency lighting unit shall be a completely self-contained lighting unit designed to provide emergency illumination upon loss of normal power. Unit contains battery, automatic charger, transfer device, lamps, and testing features.
   2. Emergency Operation: When normal voltage drops below 80% nominal, unit shall activate to operate lamps from emergency battery. Lamps are off during normal operation.
   3. Testing Features: Units shall be provided with a test switch to simulate the operation of the unit upon loss of normal power. It shall also be provided with pilot light indicating connection of normal power and a pilot indicating high rate charging status.
   4. Emergency Lighting Units shall be third party listed as emergency lighting equipment.

B. Emergency Battery: Battery shall be 12VDC sealed, maintenance-free nickel-cadmium sized for a minimum of 90 minutes operating endurance. It shall also be a high temperature type with an operating range of 0°C to 60°C and contain a resealable pressure vent. Exterior units shall be rated to a minimum temperature operating range of -18°C/0°F. Battery shall have normal life expectancy of 10 years. See Warranty requirements Part 1.

C. Battery Charger: Battery charger shall be fully automatic solid state type, full wave rectifying, with current limiting. Charger shall restore the battery to its full charge within 24 hours after a discharge of 90 minutes under full rated load.

2.7 FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section “Hangers and Supports”, for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Refer to “Light Fixture Mounting Detail” on plans for individual fixture support.

2.8 FINISHES

A. Fixtures: Manufacturers’ standard, unless otherwise indicated.
   1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Fixture catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a fixture may be installed.

B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

C. Install rows of fixtures accurately on straight lines unless otherwise noted on drawings. Coordinate with mechanical work.

D. Contractor shall be responsible for adjusting aperture rings on all ceiling recessed fixtures to accommodate various ceiling material thickness. Contractor shall responsible for coordinating the cut-out size in ceiling to ensure aperture covers cut-out entirely. The bottom of aperture rings shall be flush with finished ceiling or not more than 1/16" above. Under no circumstances will the aperture ring extend below the finished ceiling surface.

E. For fixtures with variable position lampholder assemblies Contractor shall confirm prior to installation proper lampholder (socket) position in field, and shall adjust, if necessary, after coordination with manufacturer.

F. Surface Mounted Fixtures: Support surface mounted fixtures from structural members other than ceiling tees.

G. Pendant Mounted Fixtures:

   1. Pendant mounted fixtures shall be supported from structural framework of ceiling or from inserts cast into slab.
   2. All pendants shall have swivel aligners located at the top ends; pendants shall be 1/2" rigid steel conduit unless specifically indicated otherwise on drawings or in specifications.
   3. All fluorescent pendant and surface mounted fixtures shall be supported with two (2) supports per four foot section or three (3) per eight foot section.

H. Bracket Mounted Fixtures: For each bracket fixture, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the fixture rigidly in design position. Flanged part of fixture stud shall be of broad base type, secured to outlet box at not fewer than three (3) points.

I. Top Re-lamping Fixtures: Top re-lamping fixtures shall have the necessary top-re-lamping screws loosened and moderately tightened, prior to installation, to assure ease of operation when re-lamping is required.

J. Mask the trims and bottoms of all lighting fixtures if necessary to protect the fixture during construction.

K. Ensure that all lamps installed are exactly as specified for each fixture type.

L. At the completion of construction clean the bottoms, the trim, the reflecting surfaces, lenses, baffles, louvers and reflector cones of all lighting fixtures so as to render them free of any material, substance or film foreign to the fixture. If the luminaires are deemed dirty by the Architect at the completion of the project, the Contractor shall clean them at no additional cost to the Owner. Luminaire components whose finishes are damaged shall be replaced at no cost to the Owner.

M. Provide labor and materials for final aiming of all adjustable fixtures under the Architect's supervision. Aiming shall take place immediately before building is turned over to Owner, after regular working hours where required.

## 3.2 CONNECTIONS

A. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

## 3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Provide instruments to make and record test results.

C. Tests: As follows:
   1. Verify normal operation of each fixture after installation.
   2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
      a. Contractor shall perform a test on each battery unit after it is permanently installed and charged for a minimum of 24 hours. Battery units shall be tested for 90 minutes and shall maintain not less than 60% of the initial emergency illumination or 87-1/2% of initial battery voltage for the duration of the test. Any unit which fails the test must be repaired or replaced, and tested again. Copy of testing report for each unit shall be sent to the Engineer.
      b. All battery tests shall be complete a minimum of 10 days prior to final inspection.

3. Verify operation of photoelectric controller and contactor.
4. Verify normal transfer to battery source and retransfer to normal.
5. Report results in writing.

D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

E. Corrosive Fixtures: Replace during warranty period.

## 3.4 CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

END OF SECTION 265100

# SECTION 268311 - FIRE ALARM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

### 1.2 SCOPE

A. This section of the specifications includes the furnishing, installation, and connection of the microprocessor controlled, addressable/intelligent reporting fire alarm equipment required to form a complete coordinated system ready for operation. It shall include, but not be limited to, control panels, alarm initiating devices, alarm notification appliances, auxiliary control devices, annunciators, power supplies, and wiring as shown on the Drawings and specified herein.

### 1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of fire alarm systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled. All products, including initiating devices and notification appliances, shall be as produced or supplied by the same manufacturer as the fire alarm control panel. Products of firms that do not maintain factory authorized service organization and spare parts stock are not acceptable for use on this project.

B. Installer Qualifications: An experienced Installer who is an authorized representative of the SNAC manufacturer for both installations and maintenance of all equipment required for this Project. The Installer technicians shall be individually certified NICET Level 2 and by the manufacturer of the equipment and trained and certified on the specific model being installed. Installer shall have at least one technician on staff certified NICET Level 3. Certification shall be current to latest release and must have occurred in the most recent 24 months. All connections to the SNAC and the systems programming shall be completed only by Installer technicians compliant with qualifications. Copies of certifications shall be submitted with shop drawings.

C. Codes and Standards:

1. NFPA Compliance: Comply with applicable requirements of NFPA-72, National Fire Alarm Code.
2. NEC Compliance: Comply with applicable requirements of NFPA-70, National Electrical Code (NEC) standards pertaining to fire alarm systems.
3. Testing Laboratory Compliance: Comply with provisions of NRTL safety standards pertaining to fire alarm systems. Provide products and components which are Listed and Labeled.
4. FM Compliance: Provide fire alarm systems and accessories which are FM approved.

5. State Building Code Compliance: Comply with applicable requirements of North Carolina State Building Code.
6. Fire Marshall Compliance: Provide fire alarm systems and accessories which are Fire Marshall approved.
7. Comply with Authority Having Jurisdiction.

## 1.4 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel. FACU Fire Alarm Control Unit.

C. HLI: High Line Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal Computer.

F. RAIL: Remote Alarm Indicating Light with test switch.

G. NRTL: Nationally Recognized Testing Laboratory

H. Network: Communications between FACP / FACU.

I. Installer: The company on site responsible for physically programming / wiring and certifying the equipment and operation of the system.

J. SNAC: Supplementary Notification Appliance Circuit Panel

K. Signaling Line Circuits may have one or more loops that are isolated from each other

## 1.5 SUBMITTALS - GENERAL

A. Submittals shall demonstrate compliance with technical requirements by reference to each subsection of this specification. Where a submitted item does not comply fully with each and every requirement of the specifications, the submittal shall clearly indicate such deviations. Identification requirements for non-complying features of items are very specific.

1. Installer Certifications: Copies of manufacturer signed certifications and NICET certifications as required above.
2. Product Data: Submit Manufacturer's technical product data, including specifications and installation instructions, for each type of fire alarm system equipment.
3. Battery Sizing Calculations. Also submit voltage drop and current draw calculations for control panel and NAC panels.
4. Shop Drawings: Submit (2) full size sets of shop drawings showing equipment, device locations, and connecting wiring of entire fire alarm system depicted on scaled architectural floor plans with Installer’s border sheet. Include wiring and riser diagrams and battery calculations and input/output matrix. Provide distance and proposed route for each notification appliance circuit. Devices shall include proposed address label. Electronic copy of architectural floor plans will be provided by Engineer in format compatible with

most recent release of AutoCAD upon request. Copies of Project Construction Documents or details there from may NOT be a part of the shop drawing submittal.

5. Authority Having Jurisdiction Submittal: Submit (1) one copy of Product Data and Shop Drawings as specified above to Authority Having Jurisdiction. Engineers shall review and approve shop drawings in North Carolina. Resubmit if required to make clarifications or revisions to obtain approval.
6. Maintenance Data: Submit maintenance data and parts lists for each type of fire alarm equipment installed, including furnished specialties and accessories. Include this data, product data, and shop drawings in maintenance manual.
7. As-Builts: Submit (3) three full size sets of scaled architectural floor plans depicting final device and equipment locations, all circuiting, and pathway and terminal cabinet locations. Include wiring and riser diagrams with battery calculations based off of installation. Also submit (3) copies of Product Data, Installation Instructions, Device Address List, System Matrix, System Status and Programming Report and all other pertinent information specified elsewhere within document.
8. Test Reports: Submit a letter and a copy of the test report indicating proper functioning of the system and conformance to the requirements of the Contact Documents, and the electrical final inspection certificate.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, the manufacturers offering products that may be incorporated into the Work must be NRTL listed for use with the existing Notifier NFS2-640(e) system and its field devices.

### 2.2 SUPPLEMENTARY NOTIFICATION APPLIANCE CIRCUIT PANEL

A. Batteries shall be completely maintenance free, shall not require liquids, fluid level checks or refilling, and shall not be capable of producing spills and/or leaks. Batteries shall be sealed gel-cell type with expected life of 10 years. Battery voltage shall be as required by the SNAC and related equipment. For North Carolina State Construction Office projects, batteries shall have enough capacity to power the fire alarm system for not less than 60 hours of standby is required. Required alarm notification time is 5 minutes for non-voice systems. Battery cabinet shall be twice the size of the batteries it will contain. NAC circuits shall not exceed 75% of maximum current load allowed.

B. Panel should be mounted in an accessible location. Panel will be labeled with source 120 VAC location, panel board identification and circuit number.

C. Appliance Circuit booster power supplies must be individually monitored by the SNAC and protected by a smoke detector per NFPA 72. They shall not be located above a ceiling, or in non-conditioned space. A 24 VDC power circuit serving addressable control relays must also be monitored for integrity. All fire alarm power supplies shall have 120-volts surge suppressors.

### 2.3 ALARM APPLIANCES

A. Strobe Lights shall be located as shown on the Drawings. Strobe lights indicated for use at exterior of the building shall be mounted at the indicated elevation and listed for use in wet locations. Strobe lights shall have the following specifications:

1. Voltage: Strobe lights shall operate on 24 VDC nominal.
2. Programming: Strobes shall field programmable without the use of special tools to provide 15/75, 30, 75, and 110 Candela output.
3. Maximum pulse duration: 2/10ths of one second.
4. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.
5. Strobe intensity and flash rate: Must meet minimum requirements of UL 1971. Provide strobe lights with specific intensity Candela (Cd) rating if such is indicated adjacent to the device symbol on the Drawings.
6. Strobes shall be synchronized

B. Audible/Visual Combination Devices shall be located as shown on the Drawings and shall comply with all applicable requirements for both Programmable Electronic Sounders and Strobe Lights. Mount devices at heights indicated on plans or 6" Below Finished Ceiling (BFC), whichever is lower.

## 2.4 INITIATING DEVICES

A. Addressable Devices - General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. Addressable devices shall comply with the following requirements:

1. Address Setting: Addressable devices shall provide an address-setting means that use rotary decimal switches configured to provide decade (numbered 1 to 10) type addresses.
2. Connections: Addressable devices shall be connected to a Signaling Line Circuit (SLC) with two (2) wires. Signaling Line Circuits shall originate as indicated on the Riser Diagram shown in the Drawings.
3. Operational Indications: Addressable initiation devices shall provide dual alarm and power LEDs. Both LEDs shall flash under normal conditions, indicating that the device is operational and in regular communication with the control panel. Both LEDs shall be placed into steady illumination by the SNAC to indicate that an alarm condition has been detected. The flashing mode operation of the detector LEDs shall be optional through the system field program. An output connection shall also be provided in the device base to connect an external remote alarm LED.
4. Intelligent Initiation Devices: All smoke detectors shall be the "intelligent" in that smoke detector sensitivity shall be set through the SNAC and shall be adjustable in the field through the field programming of the system. Sensitivity shall be capable of being automatically adjusted by the SNAC on a time-of-day basis. Using software in the SNAC, detectors shall be capable of automatically compensating for dust accumulation and other slow environmental changes that may affect performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter.
5. Device mounting Base: Unless otherwise specified all detectors shall be ceiling- mount and shall include a separate twist-lock base with tamper proof feature.

6. Sounder Base: Where indicated on the Drawings, provide bases with a built-in (local) sounder rated at 85 dBA minimum. Configure sounder bases such that sounders are activated under conditions as described or otherwise indicated on the Drawings.
7. Test Means: The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel when in the "test" condition.
8. Device Identification: Detectors shall store an internal identifying type code that the control panel shall use to identify the type of device. Device identifications shall be ether PHOTO or THERMAL.

B. Pull Stations: Addressable type, pull stations shall, on command from the Control Panel, send data to the panel representing the state of the manual switch. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Pull stations that employ a glass break rod are not acceptable.

1. Pull stations shall have a dual-action mechanism requiring two actions to initiate alarm.
2. All pull stations shall have a positive, visual indication of operation and utilize a double pole, double throw key type reset.
3. Construction: Pull stations shall be constructed of Lexan or other material suitable to the installation environment with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans. Mount devices at heights indicated on plans.
4. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

C. Photoelectric Smoke Detectors: Photoelectric smoke detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density. Unless otherwise indicated on the Drawings all smoke detectors shall be photoelectric type.

1. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.

## 2.5 MISCELLANEOUS SYSTEM ITEMS

1.

B. Isolator Module: Isolator Modules shall be provided to automatically isolate wire-to- wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop.

1. Operation: Isolator Modules shall operate such that if a wire-to-wire short occurs, the Isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section. The Isolator Module shall not require any address-setting, and its operations shall

be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.

2. Mounting: The Isolator Module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.
3. Isolation Modules shall be mounted at the same height as required for A/V devices.

C. Zone Map: Zone maps shall show entire building layout with initiating devices, remote annunciators, and SNAC. Room numbers shall reflect actual building signage, not architectural room numbers. Zone maps shall be large enough scale to read device labels easily and clearly. Do not display notification appliances on zone maps.

D. TVSS: The system shall be equipped with the following protective devices to prevent damage or nuisance alarms by nearby lightning strikes, stray currents, or voltage transients. The devices are to be provided by the fire alarm equipment supplier:

1. On AC Input: A feed-through (not a shunt-type) branch circuit transient arrestor such as the EFI HWM-120, Leviton OEM-120EFI, Northern Technologies DMK-B, Transtector ACP100BWN3, or equivalent UL Listed device by Square-D or EIT. Install in a listed enclosure near the electrical panelboard and trim excess lead lengths. Wind small coil in the branch circuit conductor, within panelboard, downstream of the suppressor connection. Coil is to be about 1" diameter, 5 to 10 turns, and tie-wrapped.
2. On DC Circuits Extending Outside Building: Adjacent to the FACU, and also near point of entry to outlying building, provide "pi"-type filter on each leg, consisting of a primary arrestor, series impedance, and a fast acting secondary arrestor which calmps between 30 and 40 Volts. Acceptable models include Innovative Technology D2S33-2ML, Simplex 2081-9027 and 2081-9028, Transtector TSP8601, Ditek DTKxLVL series, Citel America B280-24V, and Northern Technologies DLP-42, or equivalent by Square-D or EIT.

E. Wire

1. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, THHN/THWN, color-coded insulation.
   a. Low-Voltage Circuits: No. 18 AWG, minimum.
   b. Line-Voltage Circuits: No. 12 AWG, minimum.
2. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer. Data Loop wire shall be shielded pair #18 AWG, 30 pf/ft capacitance or less, unless specifically prohibited by the equipment manufacturer and stated on the wiring submittal

## PART 3 - EXECUTION

### 3.1 FIRE ALARM SYSTEM INSTALLATION AND CONFIGURATION

A. Connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.

1. All connections at the SNAC must be made by the Manufacturer's authorized, factory trained representative (rather than by the electrical contractor).

B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

1. All system components shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place *(e.g*., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load. Adhesives are not permitted to mount fire alarm system components to building surfaces or structure.

C. Circuit Breaker serving SNAC shall be lockable and locked in the “ON” position.

D. All addressable loop controller circuits must be "Class A" and shall have a minimum of 20% spare addresses for future use. "T-taps" from the loop are not permitted. To minimize the impact of a wiring fault on the system, isolation modules must be provided as follows:

1. For each circuit extending outside the building.
2. Within 15 feet of the SNAC, at each end of the loop.
3. At the Terminal Cabinet, at each end of the loop.
4. Minimal of (1) midway through the loop address scheme. Additional modules shall be provided after each 20 devices or control points on each addressable circuit.
5. Isolation modules not located at the SNAC shall be mounted readily visible in unfinished spaces (i.e. electrical rooms, mechanical rooms, and janitorial closets) only at same height as audio/visual devices.

E. Manual Pull Stations shall be mounted semi-flush within recessed back boxes

F. Visible signals must be the strobe (flash discharge) type, with white or clear lens, and shall comply with current ADA requirements for intensity, placement, and synchronization.

G. All supervisory trouble signals shall be different and distinct from a normal system trouble and shall be non-silenceable.

H. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceways and Boxes." Conceal raceway except in unfinished spaces and as indicated.

1. The exterior of all junction boxes containing fire alarm conductors shall be painted red; box interiors shall not be painted. Box covers for junction boxes containing fire alarm conductors shall be painted red on both sides. All painting of junction boxes and junction box covers shall be accomplished prior to installation of the boxes to avoid possible problems with overspray.
2. Box covers shall be labeled to indicate the circuit(s) or function of the conductors contained therein. Labels shall be neatly applied black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.
3. Provide metal back boxes or plastic skirts as manufactured by fire alarm manufacture for devices installed in a surface mounted application. Boxes shall match device in size and color.

I. All wiring shall be color coded in accordance with the following scheme, which shall be maintained throughout the system, without color change in any wire run:

| | |
|---|---|
| Signaling Circuits | Overall Red Sheath, Red (+) and Black (-) |
| Alarm Notification Circuits | Blue (+) and Black (-) |
| 24V System Circuits (HVAC) | Yellow (+) and Brown (-) |

J. Cable Splices: Any and all cable splices shall be in hinged terminal cabinets only. No splicing of conductors in outlet or junction boxes. There shall be NO splices in the system other than at terminal blocks. "Wire nuts," crimp splices, or insulation piercing type connectors are not acceptable. All terminal block screws shall have pressure wire connectors of the self-lifting or box lug type. □□Permanent wire markers shall be used to identify all splices and terminations for each circuit. For splices, use markers or other means to indicate which conductors leads to the SNAC.

K. Detection or alarm circuits shall not be installed in raceways containing AC power or AC control wiring. Within the SNAC, any 120 VAC control wiring or other circuits with an externally supplied AC/DC voltage above the nominal 24 VDC system power must be properly separated from other circuits and the enclosure must have an appropriate warning label to alert service personnel to the potential hazard.

L. Provide an engraved label on SNAC and all notification appliance circuit expansion panels identifying its 120 VAC power source. This label shall include panelboard identification and circuit number and panelboard location.

M. All wiring shall be checked for grounds, opens, and shorts, prior to termination at panels and installation of detector heads. The minimum resistance to ground or between any two conductors shall be ten megohms (10 Mõ), as verified with a megger. Provide advance notice to the Engineer of these tests.

N. The system shall be electrically supervised for open or (+/-) ground fault conditions in SLC, alarm circuits, and control circuits. Removal of any detection device, alarm appliance, plug-in relay, system module, or standby battery connection shall also result in a trouble signal. Fire alarm signal shall override trouble signals, but any pre-alarm trouble signal shall reappear when the panel is reset.

O. Supervision required: The connection between individual addressable modules and their contract type initiating device(s) must be supervised.

P. Spare Parts: Provide the following spare parts with the system, each individually packaged and labeled. For percentage quantities round number up to the next larger whole number.

| | |
|---|---|
| Fuses | (2) of each size used in the system |
| Indoor Strobes | 4% of installed quantity |
| Spot Smoke Detectors | 6% of installed quantity |
| Spot Smoke Detectors, Bases | 2% of installed quantity |
| Isolation Modules | 4% of installed quantity |
| Isolation Bases | 4% of installed quantity |
| Manual Stations | 2% of installed quantity |

3.2 SMOKE DETECTORS

A. Do not install detector heads until building is clean. Provide dust covers for bases throughout construction. Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed. Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.

B. A spot type smoke detector shall be provided within 15’ from SNAC, auxiliary panels, power extenders, NAC expansion panels and other control equipment. As NAC expansion panels and power extenders are not shown on drawings, additional detectors not shown shall be added required to meet this provision.

C. When installed in a room, detectors shall be oriented so their alarm light is visible from the nearest door to the corridor, unless Remote Alarm Indicator Light (RAIL) equipped.

D. Spot type smoke detectors mounted within 12 feet of a walking surface shall have their built-in locking device activated. Unless suitably protected against dust, paint, etc., detectors shall not be installed until the final construction clean-up has been completed. Contaminated detectors must be REPLACED by the Contractor at no additional cost to the Owner.

E. Ceiling-Mounted Smoke Detectors: Not less than 4 inches (100 mm) from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet (9 m) apart in any direction.

F. Wall-Mounted Smoke Detectors: At least 4 inches (100 mm), but not more than 12 inches (300 mm), below the ceiling.

G. Smoke Detectors near Air Registers: Install no closer than 36 inches (1520 mm).

3.3 EXISTING FIRE ALARM CONTROL PANEL PROGRAMMING

A. Programming of the existing FACP and new SNAC panel and connection of all circuits shall be performed by person meeting requirements listed in Quality Assurance paragraph.

B. The complete configuration data (site-specific programming) for the system must be permanently stored and archived by the manufacturer or authorized distributor. A copy of this data must be submitted to the Engineer for transmission to the Owner when the system is commissioned.

C. The Manufacturer or authorized distributor must maintain software version (VER) records on the system installed. The system software shall be upgraded free of charge if a new VER is released for any reason during the warranty period. For any new VER to correct problems, free upgrade shall apply during the entire life of the system.

D. In addition to the system tests and certification described elsewhere, the Manufacturer or authorized distributor must 100% test all site-specific software functions for the system and provide a written test report or detailed check list. This documentation must include a system operation matrix showing the actual SNAC response for each initiating device input.

3.4 SYSTEM LABELING

A. Detectors and initiating devices: Identification of individual detectors is required by a unique alphanumeric label. These device labels, which must also be shown on the shop drawings, shall be permanently affixed to the detector base. Device labels may not be affixed to the device head. Identification labels must be printed labels with black lettering on a clear background. Handwritten labels or labels made from embossed tape are not acceptable.

1. Loop 1 shall be assigned to the lowest floor devices and loop number shall increase with floor number. Device number starts in the same location on each floor and increase accordingly as circuit location increases.

B. Notification Appliances: Notification appliances shall be clearly labeled with NAC panel and circuit number. Add “EOL” designation to label where an end-of-line resistor is located in the junction box behind the notification appliance.

C. System Equipment: Provide an engraved label identifying its 120 VAC power source. This label shall include panelboard location, identification, and circuit number. Labels shall be provided for auxiliary panels, NAC panels, and power extenders.

D. Zone Map: Provide updated framed zone map at SNAC and at all remote annunciators. Update the existing FACP to include the new Storage Building zones.

E. Floor Plans with Device Numbers: A copy of the floor plans shall be provided in the control panel. A separate sheet shall be provided for each floor. Plans shall be reduced in size from engineering plans in order to fit on 11x17 sheets. All device addresses shall be clearly labeled on plans. Minimum printed text size shall be 0.75/10”. Indicate location of all cabinets, modules, and end of line resistors. Plans shall be laminated and bound in book form. Provide legend for symbols. Provide holder for plan book in panel or in a locked box adjacent to panel keyed to match panel. Provide label for box and book.

## 3.5 PHYSICAL PROTECTION

A. Manual pull-stations: Provide indoor protective shield. Lifting the clear plastic cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

B. Visual alarm appliances: Provide protective wire guards, manufactured specifically for strobes, for all stobes/visual alarm appliances located in gymnasiums, multi-purpose rooms, weight rooms, and other areas where appliances are subject to physical damage. Visual alarm appliances located in kitchens shall be direct-spray waterproof.

## 3.6 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer. Replace damaged units.

# PART 4 - SYSTEM TESTING & CERTIFICATION

## 4.1 TESTING

A. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

1. Minimum System Tests: Minimum test shall be a 100% operation test including, but not limited to the following-

a. Verify the absence of unwanted voltages between circuit conductors and ground.
b. Test all conductors for short circuits using an insulation-testing device.
c. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
d. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
e. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
f. Test all initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
g. All circuits shall be tested for supervision. Signal Line Circuits shall be tested for "Class A".
h. All control circuits (AHU shutdown) shall be tested for proper operation on an alarm condition and for wire supervision.
i. Check zone map for proper location of all devices. Verify that devices and wire are properly labeled.
j. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all audible notification signals for routing, clarity, quality, freedom from noise and distortion, and proper volume level.
k. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

B. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

C. Engineer's Test: After the pretest has been completed and the system is clear of trouble all test documentation including a printout of all custom labels and a NFPA 72 "Record of Completion" form shall be submitted to Engineer for approval. At that time Engineer may, at his discretion, perform a 100% functional test of the fire alarm system. The Contractor and the Manufacturer's authorized representative that installed the system must be present. Should the results of this test not be satisfactory, then corrections will be made and a re-test will be required at the Contractor's expense.

D. Authority Having Jurisdiction Inspection/Test: Only after Engineer has approved the system the design professional will schedule the inspection. The Contractor and the Manufacturer’s authorized representative must be present for test. Provide a minimum of 10 days' notice in writing to the Engineer for the Authority Having Jurisdiction Inspection/Test. Contractor shall provide all equipment necessary to fully test the system including test smoke, ladders, radios, or other items required for a complete test.

E. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.

F. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.

G. Closeout: After successful completion of inspections and tests, the warranty period begins. In the event of malfunctions or excessive nuisance alarms, the Contractor must take prompt corrective action. The Owner may require a repeat of the Contractor’s 100% system test, or other inspections. Continued improper performance during the warranty period shall be cause to require the Contractor to remove and replace the system.

## 4.2 TEST EQUIPMENT

A. Contractor shall provide two-way radios, ladders, smoke candles or test magnet, and any other materials needed to test the system.

## 4.3 OWNER’S TRAINING/DEMONSTRATION

A. The Manufacturer’s authorized representative shall provide training for the Owner’s designated employees in proper operation of the system and in all required periodic maintenance. Scheduling of training must be arranged to meet the Owner’s schedule. The instruction shall include a minimum of three (3) copies of a written, bound training summary, for future reference. Basic operating instructions shall be framed and mounted at the SNAC.

B. Training shall cover the following topics as a minimum:

1. Preventative maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
2. Overall system concepts, capabilities, and functions. The Owner shall be able to add or delete devices to the system and to take any device out of service and return any device to service without need for Manufacturer's approval.
3. Explanation of all control functions, including training to program and operate the system software.
4. Methods and means of troubleshooting and replacement of all field wiring and devices.
5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided on CD and shall be left with the Owner at the completion of training for the Owner’s use in the future.

4.4 DOCUMENTATION

A. The Contractor shall provide the Engineer with three (3) copies of the following:

1. As-built floor plans with device numbers, wiring and conduit layout diagrams, including wire color code and/or label numbers, and showing all interconnections in the system. Provide on paper and in AutoCAD 2021 or later electronic media format.
2. Electronic circuit diagrams of all control panels, modules, annunciators, communications panels, etc.
3. Technical literature on all major parts of the system, including control panels, batteries, detectors, manual stations, alarm indicating appliances, power supplies, and remote alarm transmission means.

B. The Contractor shall provide the Owner with three (3) interconnection cables to connect the fire alarm system to a PC.

4.5 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 268311

# SECTION 311000 – CLEARING & GRUBBING

## PART 1 - GENERAL

1. 1: Scope:

A. Related work specified elsewhere:

(2) Earthwork
(3) Erosion and Sediment Control

B. Work included in this section:

(1) Clearing with grubbing or grinding stumps, "chipping" all tree limbs and vegetation less than 6" diameter, removal of vegetation, trees, shrubs, roots and stumps that are required to be removed within the limits of work.
(2) Protection of existing vegetation, trees and shrubs to remain.
(3) Removal of dead and damaged limbs of trees to remain.
(4) Installation of temporary tree protection fence.
(5) Stockpiling of chipped materials for distribution on the site by this Contractor within the areas of existing trees to remain or as directed by the Owner's Representative.

1. 2: Existing Conditions:

A. Site Conditions: The Contractor shall visit the site, familiarize himself with actual conditions and verify existing conditions in the field. Previous surveys may be examined at the Architect's office. No extra payment will be made for errors caused by the Contractors failure to inspect the site and review all information.

B. Acceptance: The Contractor shall accept actual conditions at the site, and perform the work specified herein without any additional compensation for possible variation from grades and conditions depicted on the drawings, whether surface or subsurface, except as provided for in the Contract Documents.

C. Utilities: The Contractor shall contact NC One Call and other agencies and public utility companies to determine location and elevation of all public utilities on site prior to beginning work. The Owner shall provide available information to assist contractors in locating any private utilities on the site.

D. The extent of trees and/or tree mass areas to remain is indicated on the drawings and shall be protected by tree protection fence (See detail/notes on plan).

1. 3: Protection:

A. Bench Marks & Monuments: Maintain carefully all bench marks, monuments, and other reference points. If disturbed or destroyed, the Contractor shall replace to original condition or as directed by the Owner. If benchmarks or monuments are found at variance with the drawings, the Contractor shall immediately notify the Owner's Representative and not proceed with layout work until receiving corrections or adjustments from the Owner.

B. Protection of Existing Work to Remain: All existing curbs, sidewalks and paving to remain, which are damaged in the performance of this work, shall be restored to original condition as directed by the Owner at no additional cost to the Owner.

1. 4: Disposition of Existing Utilities:

A. Rules and regulations of the authority having jurisdiction shall be followed in executing all work.

B. Active utilities shall be adequately protected from damage and removed or relocated only as indicated or specified. Where active utilities are encountered, but are not indicated on the drawings, the Owner shall be immediately notified. The utility shall be properly protected, supported or relocated as directed by the Owner. The Contractor shall be held responsible for any damage to underground or overhead utilities and shall promptly repair and restore services at no additional cost to the Owner.

C. Inactive utilities encountered during the execution of this work shall be removed, plugged or capped as directed by the Owner or the utility company involved.

PART 2 - PRODUCTS

2. 1: Fill Material:

A. Fill material for holes left by removed stumps shall be filled as specified herein and in Section 312000. All fill material shall be free of roots, wood, or other visible organic matter that might decay or rot and compromise future structural integrity of the fill.

2. 2: Topsoil:

A. Topsoil shall be stripped, cleaned, screened per requirements outlined in Section 312000 and stockpiled on the site for later use.

B. Temporary brush piles and stumps shall be located so as not to adversely affect site access or hinder other operations underway, including stripping of topsoil.

C. Stump removal and grubbing shall not mix subsoil with overlying topsoil.

D. Do not over excavate the topsoil, especially in areas to receive non-structural fill. The Soils Testing Firm shall be present during stripping operations.

2.3: Chipped Materials:

A. All cleared vegetation less than 6” diameter, including cleared limbs and saplings, shall be chipped and stockpiled in locations on the site for re-distribution by this Contractor as temporary erosion control mulch and at the perimeter of areas containing existing vegetation and as otherwise directed by the Owner’s Representative.

PART 3 - EXECUTION

3. 1: Preparation:

A. This Contractor will review and define the existing Trees and/or Tree Mass Areas to remain in the field with the Architect, Landscape Architect and Owner and flag existing trees for removal. Install Tree Protection Fence where required to protect trees to remain.

3. 2: <u>No burning</u> will be allowed on the site at any time.

3. 3: Protection of Existing Trees to Remain and Undisturbed Areas:

A. Fencing: Trees to remain are protected by temporary fences constructed of plastic safety fabric as required, to provide complete protection. Erect fences to protect feeding roots of trees generally located inside the drip line or perimeter of spread.

B. Cutting: Do not cut low-hanging branches on trees to be saved, unless approved by the Architect. Any such branches that must be cut to eliminate obstructions shall be pruned by a qualified tree surgeon. Any such cuts or any accidental injuries to the bark, trunk or roots shall be immediately repaired and properly trimmed and painted with a protective tree wound and sealing compound approved by the Architect.

C. This Contractor shall not stage materials or move equipment in areas of existing trees to remain.

3.4: Coordination of Topsoil Stripping (Refer to Section 312000):

A. Where potentially soft wet surface conditions occur across the site, stripping of topsoil shall be performed using properly tracked equipment instead of heavy rubber tired machinery (scrapers, dump trucks, etc.) in order to prevent rutting and disturbance of near surface soils.

B. Temporary brush piles and stumps shall be located so as not to adversely affect site access or hinder other operations underway, including stripping of topsoil.

C. Stump removal and grubbing shall not mix subsoil with overlying topsoil.

3. 5: "Warping" of Grades:

A. Grades surrounding trees to remain shall be warped up or down, when possible, between existing grades in the root zone and finished grades. Do not disturb root systems of existing vegetation. Fill material in voids left by stump removal shall be as specified in Section 312000 - Earthwork.

3. 6: Prohibited Work:

A. Stripping of topsoil, cutting or filling, burning of trash or dumping of materials will not be permitted within the spread of branches of trees to remain unless specifically approved in writing by the Architect.

3. 7: Drainage Management:

A. During clearing and hauling operations, make every effort to maintain site drainage patterns compatible with erosion control measures. Minimize construction traffic during wet periods. Provide temporary drainage ditches with temporary pipe crossings as necessary to keep the site dry and workable.

END OF SECTION 311000

# SECTION 311010 – EROSION AND SEDIMENT CONTROL

## PART 1 - GENERAL

### 1.1: Scope

A. Related work specified elsewhere:

1. Selective Site Demolition (Section 024113)
2. Landscaping (Section 329300)

B. See plans for proposed erosion control measures and additional information. The Contractor shall request and receive from the Engineer a copy of the approval letter issued by the State. No demolition, construction, or land disturbance activities shall begin until all applicable erosion control measures have been installed. If clearing is required for installation of a given measure, all other measures shall be installed first. The necessary land disturbance activities required for installation of the given measure may then proceed. All measures shall be in accordance with the North Carolina Department of Environment Quality (NCDEQ) NC Division of Energy, Mineral, and Land Resources (NCDEMLR) for compliance with state law (Sedimentation and Pollution Control Act of 1973, and any subsequent amendments).

C. See the NC Erosion and Sediment Control (E&S) Manual and any subsequent amendments, for details, procedures and practices expected for compliance with these specifications.

D. The extent of major requirements is indicated on the drawings. This Contractor shall adhere to the approved sequence of construction and installation of erosion control measures as detailed. The Contractor shall be responsible for monitoring the effectiveness of the erosion control measures, and repairing, replacing or modifying the control measures as required to effectively control siltation and erosion, including the protection of public rights-of-way and points of storm water discharge.

E. No change orders or modifications to the Contract amount shall be allowed for relocation, readjustments, or modifications to erosion control measures required to contain all sediment on the site. This Contractor shall accept full responsibility for the performance of containing all sediment on the site and any penalties that might be assessed to the Owner because of the failure of any measures shall be paid by this Contractor.

F. **Temporary grassing shall be installed on all graded areas within 15 calendar days of last disturbance** as per the NCDEQ NCDEMLR E&S Manual, as contained herein, and on the drawings.

G. The Contractor shall purchase and maintain a copy of the NCDEMLR E&S Manual for immediate reference at the job site at all times. Refer to this manual for details, procedures and practices expected for compliance with these specifications.

H. The Contractor shall clean out all measures a minimum of once each month and as necessary to remain in compliance with Regulatory Standards and perform a final cleaning, disposal of silt on-site, re-grade to convert to final storm water control measures and stabilize final finish grades per the requirements of the Contract.

I. Submit samples of all erosion control products for review and approval prior to purchase and installation.

J. The Contractor shall inspect each erosion control device a minimum of once per week and after any ½" or greater rainfall event. Results of each inspection shall be signed and recorded by the inspector for each device in a loose-leaf three ring binder kept on the site for the duration of the site construction.

PART 2 - PRODUCTS

2.1: See the NCDEMLR E&S Manual for materials permitted with details required. This site shall be deemed to be in the Piedmont geographical area of North Carolina.

2.2: Any materials not meeting the requirements of the NCDEQ Standards / Town of Garner (Wake County) must be approved in writing by the Owner's Representative.

2.3: Erosion Control Details Used - See Plans.

2.4: Temporary Grassing: See Plans.

2.5: Temporary Silt Fence:

A. Fabric: Geotextile fabric may be a pervious sheet of polypropylene, nylon, polyester or polyethylene yarn which is certified by the Manufacturer or Supplier to conform to the following:

| | |
|---|---|
| Filtering Efficiency: | 85% (minimum) |
| Tensile Strength at 20% Elongation: | 30 lbs/lin. in. (minimum) |
| Slurry Flow Rate: | 0.3 gals/SF/min. (minimum) |

B. Posts: Metal posts are required. Posts must be the minimum length indicated on the drawings and be sufficient to hold wire, fabric and full sediment load without failure.

C. Wire Fabric: Wire fabric shall be welded wire fabric of size and thickness detailed. New rolls of wire or wire fabric must be used with no deformities or unusual bends.

D. Staples: As detailed.

2.6: Construction Entrances: Install where shown on the drawings. All temporary construction entrances must be repaired and reestablished like "new" each month and maintained throughout construction. Tracking of mud and debris on adjacent paved streets will not be allowed at any time. See detail on drawings.

2.7: Temporary Inlet Protection: Install as detailed and specified. Maintain no more than half of the allowed sediment storage at any time.

2.8: Turf Reinforcement Mat_(TRM) shall be similar or equal to Type 7020 Enkamat made by the AKZO Corporation, Enka, NC 28728 (800) 365-7381 or Landlok TRM 1060 by Synthetic Industries, (800) 239-3224.

2.9: Jute Mesh: Acceptable mesh will be a woven, undyed, unbleached Jute Matting supplied in 48" min. widths weighing 0.92 lbs. per square yard with an open area of 60-65% similar to product by Dayton Bag & Burlap (800) 543-3400 or a biodegradable straw blanket, one photodegradable net on topside fiber matrix supplied in 6.5 ft. wide rolls, similar to No. S75 by North American Green (800) 772-2040. See allowances and unit prices bid.

2.10: Excelsior Straw Matting: NO excelsior straw matting shall be used on the site. See 2.8 Jute Mesh above.

2.11: Tree Protection Fence: Materials for tree protection fence shall meet all current requirements of the City of Raleigh.

2.12: High Performance Turf Reinforcement Mat (HPTRM): HPTRM shall be similar or equal to "Pyramat" by SI Geosolutions. Contact information is (423) 899-0444 or (800) 621-0444 or www.fixsoil.com. Any proposed substitute must meet High Performance Turf Reinforcement Mat requirements.

PART 3 - EXECUTION

3.1: This Contractor shall follow the approved Sequence of Construction shown on the plans and all measures shall be installed and maintained as per the NC E&S Manual and approved plan.

3.2: Obtain an inspection and approval from the NC DEQ Inspector or Owner's Representative for measures required prior to beginning any grading operations.

3.3: Install and maintain all erosion control measures as required. See plans for location and extent.

3.4: Temporary Grassing: Prepare seed bed so that it is well-pulverized, loose and uniform. Apply lime according to soil test recommendations or at rates indicated here within. Add fertilizer at rates indicated and incorporate into the top 4-6 inches of soil. Evenly apply seed type at the indicated rates based on site location and time of year. Mulch area with straw and tack with asphalt, netting or other approved mulch anchoring tool. A disc with blades set nearly straight can be used as a mulch anchoring tool if properly executed.

A. Maintain temporary "Fall" grassing by repairing and refertilizing damaged areas immediately. Top dress with 50 lbs/acre of nitrogen in March. If necessary, to extend temporary cover beyond June 15, overseed with 50 lbs/acre Kobe (Piedmont and Coastal Plain) or Korean (Mountains) Lespedeza in late February or early March.

3.5: Install and maintain Turf Reinforcement Mat (TRM) and High-Performance Turf Reinforcement Mat (HPTRM) according to manufacturers recommendations and where indicated on the drawings. Do not remove TRM or HPTRM after establishment of grassing.

3.6: Install and maintain Jute Matting (erosion control blanket) per manufacturers' recommendations.

3.7: Remove all temporary erosion control measures when approved by the NC DEQ Inspector and the Engineer/Landscape Architect at the project's end. Repair all grassed areas affected by removal of temporary measures to the complete satisfaction of the Owner and the Town of Garner.

END OF SECTION 311010

SECTION 312000 – EARTHWORK

PART 1 - GENERAL

1.1: Description

A. Related work elsewhere:

1. Erosion and Sediment Control (Section 31 10 10)

B. Work under this Section includes:

1. Stripping, stockpiling and triple screening of topsoil
2. Providing temporary site drainage
3. General excavation and filling
4. Excavation, drying and replacement of excessively wet soils
5. Trenching excavation and backfilling of underground installations
6. Backfilling of structures
7. Fill compaction control
8. Authorized undercut and replacement
9. Unauthorized undercut and replacement
10. Correction of damages to existing work caused by implementation of this contract
11. Providing topsoil to meet finish grades

1.2: Job Conditions:

A. Contractor shall perform all work in accordance with the City of Raleigh (Wake County) and State of North Carolina standards that apply.

B. Contractor is responsible for securing all state and local permits required for this work.

C. Site Conditions: Existing conditions are shown on the Drawings. Contractor shall visit the site, familiarize himself with actual conditions and verify existing conditions in the field. Existing grades on the drawings are the results of field survey by the Dewberry Engineers, Inc., 2601 Wycliff Road, Raleigh, NC 27607, 919.424.3715; and are offered for relative information only. The Contractor may have access to the site and verify the information presented or develop his own information prior to submitting his bid proposal.

D. Acceptance: The Contractor shall accept actual conditions at the site, and perform the work specified herein without any additional compensation for possible variation from grades and conditions depicted on the drawings, whether surface or subsurface, except as provided for in the Contract Documents.

E. Utilities: The Contractor shall contact NC One Call and other agencies and public utility companies to determine location and elevation of all public utilities on or near the proposed area of construction prior to beginning work. The Owner shall provide any information required to locate any private utilities on the site.

F. Disposition of Existing Utilities:

1. Rules and regulations of the authority having jurisdiction shall be followed in executing all work.
2. Active utilities shall be adequately protected from damage and removed or relocated only as indicated or specified. Where active utilities are encountered, but are not indicated on the drawings, the Architect and Owners' Representative shall be immediately notified. The utility shall be properly protected, supported or relocated as directed by the Owner. The Contractor shall be held responsible for any damage to underground or overhead utilities and shall promptly repair and restore services at no additional cost to the Owner.
3. Inactive utilities encountered during the execution of this work shall be removed, plugged or capped as directed by the Owner or the utility company involved.

G. Pre-grading Conference: The Contractor will conduct a pre-grading conference with the Architect, Owner and Soils Testing Firm to review site conditions and his proposed procedures, materials and methods to be followed during the execution of this contract.

1.3: Protection of Bench Marks:

A. Bench Marks and Monuments: Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed. Elevation of the benchmark shall be verified before beginning any work. If the benchmark is found at variance with the drawings, the Contractor shall immediately notify the Owners' Representative and the Architect and not proceed with layout work until receiving corrections or adjustments from the Architect.

B. Protection of Existing Work Remaining: All surface grading, stone roads and parking areas damaged in performance of this work shall be restored without extra costs to the Owner in the manner prescribed by authorities having jurisdiction.

1.4: Make no excavations to full depth when freezing temperatures are expected, unless footings and slab can be poured or fill placed immediately after excavation has been completed. Protect excavation if placing of concrete or fill is delayed.

1.5: Excavation Classifications:

A. <u>Common Excavation</u> includes excavation of pavements and other obstructions visible on surface; underground structures, utilities, and other items indicated to be demolished and removed to subgrades indicated; together with earth and other materials encountered that are not classified as rock or authorized undercut.

B. <u>Rock Excavation for Trenches and Pits</u> includes removal and disposal off-site of materials and obstructions encountered that cannot be practically excavated with a track-mounted power excavator, equivalent to Caterpillar Model No. 330, or equivalent equipped with new rock teeth and a 3 feet wide bucket. Practical excavation is defined as the ability to remove at least 10 cubic yards during one (1) hour of continuous digging. Trenches in excess of 10 feet in width and pits in excess of 30 feet in either length or width are classified as open excavation. See allowances and unit prices bid.

C. Rock in Open Excavations includes removal and disposal on-site of materials and obstructions encountered in general excavation other than trenches and pits that cannot be dislodged and excavated with modern, track-mounted, heavy-duty excavating equipment without drilling, blasting, or ripping. Rock is defined as material which cannot be effectively excavated during general grading with a Caterpillar D-8 or equivalent bulldozer drawing a new single tooth ripper. Effective excavation is defined as the ability to remove 25 cubic yards or more of material after one (1) hour of continuous ripping. Typical of materials classified as Rock in Open Excavation are boulders larger than 1 1/2 cu. yds. or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits. See allowances and unit prices bid.

D. Unauthorized Undercut is excavation beyond indicated subgrades without a determination by the Soil Testing Firm that subgrade materials are unsuitable or the prior approval of the Owner's Representative. Unauthorized undercut shall be deemed the same as common excavation and shall not be additional cost to the Owner.

E. Authorized Undercut shall be material below indicated subgrades that is deemed unsuitable by the Soil Testing Firm and is authorized to be removed by the Owner's representative. See allowances and unit prices bid.

F. Payment: No payment shall be made on unit-price basis for rock unless the minimum sized equipment required herein is utilized and removal by drilling, blasting or wedging is deemed necessary by the Owner's Representative.

G. Measurement: Rock shall be stripped for measurement before excavating or blasting, and no rock excavated or loosened before measurement shall be allowed or paid for as rock. Authorized excavation shall be removed at the direction of the soil technician and shall be measured before placing backfill. Measurement and payment, therefore, shall be by the number of cubic yards of material required to be removed to bring the site to the grades specified in the Contract Documents. The Owner's Representative may at his sole discretion adjust the grades to minimize the quantity of material to be removed should rock or authorized excavation become excessive and exceed allowances bid.

H. Do not perform rock excavation work until rock has been cross-sectioned, classified and approved for removal by Owner's representative. Intermittent drilling, blasting, or ripping performed to increase production and not necessary to permit excavation of material encountered will be deemed to be *Common* Excavation.

I. Rock payment dimensions are limited to the following:

1. Two feet outside of concrete work for which forms are required, except footings.
2. One foot outside perimeter of footings.
3. In pipe trenches, 6 inches below invert elevation of pipe and 2 feet wider than inside diameter of pipe, but not less than 4 feet minimum trench width.
4. Outside dimensions of concrete work where no forms are required.
5. Under slabs on grade, 6 inches below bottom of concrete slab or stone sub-base.

1.6: A permanent bench mark necessary for vertical control of this project shall be confirmed and protected. Elevation of the bench mark shall be verified before beginning any work.

1.7: Sampling and Testing:

A. Soil Testing and Laboratory Service:

1. Laboratory: The Owner will employ the services of an independent soil testing laboratory to perform tests required under this Section, or waive testing requirements at his discretion.
2. The Soils Testing Firm will evaluate and approve all sub grades and fill layers before further construction work is performed thereon. Tests of subgrades and fill layers will be taken as recommended by the Soils Testing Firm and approved by the Owner. Final inspection of sub grades should be performed by the Soils Testing Firm immediately prior to foundation and slab concrete construction, placement of stone base course and other paved areas. The Contractor is responsible for notifying the soils testing firm for all inspections.
3. All initial testing shall be paid for by the Owner. Retesting shall continue until compliance is confirmed. Cost of repeating testing due to failed test shall be reimbursed to the Owner by the Contractor.
4. The Contractor shall pay for additional re-inspection services after the first re-inspection if the re-inspection fails to meet the job specifications or the area is not ready for re-inspection in the opinion of the Soils Testing Firm.
5. The Contractor shall pay for inspection costs if the inspection is cancelled without notifying the Soils Testing Firm before the technician leaves his office.
6. The testing technician at the site shall not have authority to act as the Owner's Representative and may not approve changes in the scope of work or direct the Contractors work except as provided for in these specifications.
7. The Soils Testing Firm shall verify bearing pressures under storm drainage structures prior to placement.
8. If in the opinion of the Architect, based on reports of the Soils Testing Firm and onsite inspection, subgrade or fills that have been placed are below specified density, the Contractor shall provide <u>additional compaction and testing</u> at no additional expenses to the Owner.

1.8: Compaction Standards: Required densities of compaction are expressed hereinafter in terms of percentages. Such terms shall mean percentages of maximum densities at optimum moisture content, as determined and controlled in accordance with the <u>Standard Proctor Method, ASTM D-698</u>.

## PART 2 - PRODUCTS

2.1: Topsoil – Stripped and Triple Screened:

A. Topsoil shall be defined as the upper organic horizon or cultivated horizon of the soil profile with greater than 5% by weight of fibrous organic materials visible to the naked eye. All topsoil stripped from the site for use on this project shall be

"Triple Screened" on the site by sifting through three ½" x ½" sized screens to remove rocks or debris that would hinder planting operations.

B. Imported "Triple Screened Topsoil" delivered to the site, placed and compacted as specified, may be required to meet the required finished grades on this site. This triple screened topsoil shall be a natural, fertile, friable soil, possessing characteristics of representative productive soils in the area that has been sifted through three ½" x ½" screens as in A. above. Note: Submit three bagged samples of imported "Triple Screened Topsoil" for review and approval by the Architect prior to purchase and installation.

2.2: Acceptable Fill Materials:

A. Fill material for holes left by removed debris, trees or stumps, previously excavated test pits or areas indicated on the drawings to receive "fill" shall be as specified herein. All fill materials shall be free of roots, wood, or other visible organic matter that might decay or rot and compromise future structural integrity of the fill.

B. Use only suitable excavated material for required fills. The Owner may employ the services of an independent soil testing laboratory to perform tests at the site. Any material deemed unacceptable by the soils testing firm present shall not be used, unless and until adjustments or modifications are made acceptable to the Soils Testing Firm.

C. All structural fill or backfill shall be low plasticity soils unless approved by the Soils Testing Firm (liquid limit less than 50%; plasticity index less than 20% for soils containing more than 50% passing a number 200 sieve), be free of organic material (i.e. soils containing less than 5% by weight of fibrous organic materials) and debris. Any partially weathered rock may be used as structural fill provided it can be broken down by the excavation and compaction equipment into particles with a maximum dimension of six (6) inches and blended with soil to the satisfaction of the Soils Testing Firm.

D. The following maximum particle sizes shall apply for all <u>fill material</u>:

1. Building Area within top 4 feet below design subgrade elevation: 3 inches
2. Building Area greater than 4 feet below design subgrade elevation: 6 inches.
3. Parking/Paved Areas within top 3 feet below design subgrade elevations: 3 inches
4. Parking/ Paved Areas greater than 3 feet below design subgrade elevation: 12 inches
5. Playfield Areas within top 3 feet below finish grade elevation: 1 inch
6. Playfield Areas greater than 3 feet below finish grade elevation: 12 inches
7. Landscape Areas to receive Trees or Shrubs within the top 3 feet below finish grade elevation: 3 inches

*When placing a soil-rock blend, care must be used to blend soil with rock pieces so that excessive voids are not created. In no case should rock pieces be stacked on top of each other without adequate soil between them. Rock pieces should not be placed in any area where local excavation (for utility lines or other purposes) will be required.*

2.3: NCDOT #57 washed stone or other graded stone approved by the Soils Testing Firm and Architect may be used as backfill for areas excavated below indicated subgrades. See allowances and unit prices bid.

2.4: Unsuitable Soil: The Soils Testing Firm shall identify *Unsuitable Soil*. Soils shall not be considered unsuitable solely due to moisture content. Unsuitable soil shall be spread onsite in areas where directed by the Owner's Representative <u>if</u> required by the testing firm. Unsuitable soil materials are defined as those complying with ASTM D 2487 soil classification groups OL, OH, and PT. High moisture soils will be looked at on a case –by-case basis. If it is determined that discing and aerating the soil will take more than <u>48 hours</u> during acceptable weather conditions and will impact the critical path of the schedule and that the only way to maintain the schedule is to import suitable fill, then soils that are too wet to achieve adequate compaction will be classified as "unsuitable" and replaced in accordance with the allowances. The Owner's representative must approve of any soils being classified as "unsuitable" due to moisture content.

2.5: Suitable Soil: Suitable soil materials for fill are defined as those complying with ASTM D 2487 soil classification groups GC, GW, GP, GM, SM, ML, SW, SC, CL and SP. The use of MH and CH soils for structural fill may be allowed in the lower portions of the fill but not in the upper 3', and will only be placed at the discretion of the Soils Testing Firm.

2.6: Offsite Material (Borrow): If offsite material is required for this Contract, the Contractor shall be responsible for compliance with all regulations and requirements of the City of Raleigh (Wake County) and the North Carolina Department of Environmental Quality at any necessary borrow locations. In addition, any local requirements or fees shall also be the Contractor's responsibility. See allowances and unit prices bid.

A. Materials from offsite that are used as part of an allowance shall be measured in a manner acceptable to the Owners' representative and the Architect. The location of the offsite borrow pit shall be approved by the Architect prior to commencement of any hauling operations.

B. All off-site material shall be approved by the Soil Testing Firm prior to use. Suitable materials for off-site fill are defined as those complying with ASTM D2487 soil classification groups GP, GM, SM, SC, CI, and SP. Offsite material (Borrow) shall meet a maximum dry density of at least 100 pcf per ASTM D-698.

2.7: Surplus and Unsuitable Materials: Unsuitable materials and surplus excavated materials must be removed from the site and disposed of legally.

2.8: Settlement Hubs: Settlement hubs shall consist of a metal pipe or piece of reinforcing steel that is grouted into a hole excavated at least 12 inches below the ground surface. A piece of PVC pipe should be placed on the outside of the hub to protect it.

2.9: Sand: Clean sand containing less than 3 percent, by weight, of particles finer than the U.S. Standard No. 200 mesh sieve.

2.10: Geotextile Filter Fabric: Non-woven synthetic fabric capable of preventing clay and small soil particles from migrating into drainage structures. Acceptable products Mirafi 140N or equal. See allowances and unit prices bid.

2.11: Geogrid: High density polyethylene plastic geosynthetic formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, ABC or backfill function primarily as reinforcement. Acceptable product Tensar BX1100 or equal. See allowances and unit prices bid.

2.12: Geotextile Subgrade Reinforcement Fabric: Woven synthetic fabric for reinforcement of soil subgrades. Acceptable products include Mirafi 500X or equal. See allowances and unit prices bid.

2.13: Screenings Backfill for Modular Concrete Retaining Walls: Acceptable backfill for the reinforced zone behind the fabric encased Washed No. 57 Stone zone shall consist of material commonly referred to as "crushed stone screenings" acceptable to the Contractor's Professional Engineer responsible for the design of the retaining wall system.

2.14: Flowable Fill: Shall meet requirements for <u>Non-Excavatable</u> fill as specified in NCDOT Section 1000-6 and Table 1000-1.

PART 3 - EXECUTION

3.1: Preparation:

A. Layout: Grade stakes and any extension of reference benchmarks shall be laid out by a North Carolina Professional Land Surveyor, or someone under his direct supervision, and certified by the same. All drainage swales, drives, walks and other site improvements shall be staked. Layout work shall be referenced to base lines. All stakes in the field shall be identified and marked with cut or fill indications in a manner easily interpreted by the Contractor, Owner's Representative and Architect.

B. Verification of Existing Conditions: Where new grades tie into existing grades, the existing grades shall be verified by the Contractor. If existing conditions are at variance with the drawings, the Architect shall be immediately notified and adjustments made only as directed by the Owner.

C. Drainage Management: During grading and hauling operations, the Contractor shall make every effort to maintain site drainage and to minimize construction traffic during wet periods. Conduct grading operations only when the site is sufficiently dry. Use proper equipment to prevent rutting and disturbance of near surface soils. Provide temporary drainage ditches as necessary to keep the site dry and workable.

D. Shore and brace all excavations if required to prevent cave-ins. Such shoring shall not be removed until permanent supports are in place. NO STANDARDS LESS THAN OSHA STANDARDS WILL BE ACCEPTABLE.

E. Any human remains uncovered during the course of excavation shall immediately cause work in that area to cease. Notify law enforcement officials and the Owners' Representative and the Architect immediately.

F. Temporary Storage of Material: All material shall be mounded with slopes less than the angle of repose for the type of materials excavated. Material shall not be pushed back into trenches or excavated holes at a greater rate than the lifts specified herein.

G. Public Safety: For the safety of other workers and the general public, all open trenches and excavations shall be clearly identified and barricaded including posting warning lights as necessary to prevent accidents.

I. Excavate subgrade and take necessary precautions such as stripping with truck equipment to keep from rutting topsoil into the subsoils creating an apparent thicker topsoil thickness.

3.2: Topsoil Stripping:

A. Strip topsoil to depths recommended by the Soil Testing Firm from all "cut" areas and from "fill" areas under buildings and pavements to receive structural compacted fill. Topsoil shall be defined as the upper organic horizon of the soil profile. Previously cultivated soils located below the upper organic horizon should not be considered as topsoil and should not be stripped. Do not allow mixing of subsoil clay and other materials with the topsoil. Remove all rocks and roots by sifting topsoil through three ½" x ½" screens. Confirm with soil testing laboratory that subgrades are dry enough not to rut topsoil (See I. above)

B. Stockpile topsoil in areas approved by the Owners' Representative and the Architect. Provide for erosion control around the stockpile and temporarily grass the stockpile surface according to Town of Fuquay-Varina and NC DENR standards.

C. A small amount of subsoil, proven to meet the general requirements for topsoil, may be stockpiled for future spreading in areas to receive "topsoil" at the discretion of the Soils Testing Firm and Owner's Representative.

D. Topsoil shall be incorporated into the construction in the following priorities:

1. Grass landscape areas (6" deep minimum)
2. Grass Play fields (6" deep minimum)
3. Plant beds, median islands and backfill shoulders (4" deep minimum)
4. Incorporate into fill of slopes and areas to receive seeding and "no-mow" vegetation (4" deep minimum)

E. The Contractor shall select the locations of the topsoil stockpiles and receive approval from the Owner's Representative prior to placement. Screening, redistribution and spreading of the stockpiled topsoil to meet finish grades is part of this Contract.

3.3: If "Rock" or "Unsuitable" soil is encountered, immediately notify the Owner's Representative. The Contractor shall demonstrate at no additional cost to the Owner and Testing Firm that the rock cannot be ripped with the specified equipment operated in the lowest available gear and at the highest operating RPM. Also, see paragraph 3.10 in this section.

3.4: Excavation and Filling shall be conducted in a manner planned to promote job progress.

A. Keep excavations free of water. Refer to dewatering procedures hereinafter specified.

B. Do not deposit any fill on a subgrade that is muddy, frozen or that contains frost.

C. Place no backfill until foundation walls have sufficiently cured to withstand pressure of backfilling and compacting operations.

D. Fill lifts shall not be greater than 8" deep loose thickness, placed in successive horizontal layers for the full width of the cross-section.

E. Provide clean unfrozen fill materials free of substances subject to rot, corrosion and termite attack.

F. Prior to placing fill material, the surface of the ground shall be scarified to depth of 6" and the moisture content of the loosened material shall be such that it will readily bond with the first layer of fill material.

G. Subgrades may be proofrolled at the option of the Soil Testing Firm to determine acceptance prior to fill placement. Unacceptable subgrades and subgrades considered unstable as indicated by proofrolling shall be repaired to the satisfaction of the Soil Testing Firm before fill is placed. Proofrolling shall be performed with a loaded dump truck or similar weighted rubber tired equipment as approved by the Soil Testing Firm.

H. If necessary, soil shall be moistened, or allowed to dry to correct moisture content before compaction. Remove and replace or scarify and "air dry" soil material that is too wet to permit compaction to specified density. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory level as determined by the Soils Testing Firm. Contractor shall supply a farm tractor and a disk with minimum 24 inch diameter disks. Contractor shall turn the soil every 30 to 45 minutes during favorable weather during drying operations. The surface of the area being dried shall be sloped to drain and shall be sealed with a smooth drum or rubber tired roller each night and prior to predicted rain events. The Contractor is responsible for achieving required soil moisture without additional compensation for wetting or drying.

I. The Contractor shall expect and prepare for repair of the upper <u>1 to 3 feet</u> of surface soils across a portion of the project due to the soft wet condition of those materials. This repair may involve but is not limited to the excavation, removal, spreading and drying of wet surface soils and then hauling the dried soils back to the excavation for placement and compaction. Drying of the soils in this manner to achieve adequate compaction and stability will be performed at no additional cost to the Owner. Procedures for repair of subgrade soils must be approved by the Soil Testing Firm prior to the initiation of the repairs.

3.5: Trenching Excavation and Backfilling shall be Common Excavation. All material encountered, other than authorized undercut, shall be moved as necessary to achieve grades indicated, and to install utilities at grades required.

A. Structures: The Contractor shall not begin any backfilling operations against any structural walls, posts, or other structures until the structure has attained at least 90% of its design strength. In no case shall the Contractor begin any backfilling operations until specific permission has been obtained from the Owners' Representative and the Architect.

B. Do not backfill excavations for structures and pipe lines until work within the excavations is completed and approved by the Owners' Representative and the Architect.

C. See a. through e. in 4. above.

D. Backfill against both sides of a wall simultaneously and evenly.

E. Backfill by hand around piping.

F. Exercise care to avoid damage to piping or coatings.

G. Deposit fill in layers not more than 6" thick in areas where high frequency vibratory tamper must be used in lieu of large rolling equipment.

H. Trenching backfill under building slab, pavement, and sidewalks must comply with compaction control for those areas.

3.6: Excavation for Pipe Lines:

A. Excavation for pipe lines shall be done to lines and grades shown on drawings or as required by field conditions. Trench widths at top of pipe shall not be wider than necessary to accommodate pipe size. At the option of the Contractor, bottom of trench shall be shaped to conform to bottom quadrant of pipe barrel, or pipe may be laid on a stone bedding.

B. If the Contractor chooses to use stone bedding for pipe lines it shall be crushed stone or other approved granular material not larger than 3/4 inch, nor smaller than 1/4 inch in size. Stone bedding shall extend full width of pipe and a depth of from top of pipe to a minimum of not less than 4 inches under pipe barrel or bell as applicable. Bell holes shall be made at all joints before pipe is lowered into place and shall be adequate for work required.

3.7: Fill Compaction Control - Required densities of compaction are expressed hereinafter in terms of percentages. Such terms shall mean percentages of maximum densities at optimum moisture content, as determined and controlled in accordance with the Standard Proctor Method, ASTM D-698.

A. All structural fill (fill placed in load bearing areas or slopes including under the building slab, pavement, and sidewalk areas), shall be placed in loose lifts not exceeding 8" and be compacted to at least 95 % Standard Proctor, except for the top 12” depth which is required to be compacted to 98% Standard Proctor.

B. Fill material being placed in non-load bearing or under lawns and planted areas, shall be compacted to a dry density of at least 92% Standard Proctor for full depth of fill.

C. Fill slopes steeper than 4:1 (horizontal to vertical) shall be plowed, stepped and leveled.

D. Consult with Soils Testing Firm for compliance in all areas.

D. Compactions listed are at a moisture content of +/-3 percent of the optimum content. This Contractor is responsible for modifying soil (either drying or wetting) to achieve the required moisture level.

E. Percentage of Maximum Dry Density Requirements:

1. Compact soil under pavements within NCDOT rights-of-way or new pavement to be constructed to NCDOT standards compact the top 8 inches below pavement subgrade to at least 100% density in accordance with AASHTO T-99 as modified by NCDOT.
2. Compact each layer of aggregate base material under pavement within NCDOT rights-of-way or new pavement to be constructed to NCDOT standards to 100% density in accordance with AASHTO T-180 as modified by NCDOT.

3.8: Compaction Equipment:

A. Compaction equipment for confined areas shall be mechanical equipment equal to or better than Rammex, Dart Soil Compactor or hand held machine tampers.

B. Compaction for large areas shall be accomplished by the use of power rollers, sheep's-foot rollers, machine tampers, or other approved mechanical equipment.

3.9: Authorized Undercut and Replacement:

A. When authorized by the Owner's Representative, the Contractor may be required to undercut unsuitable materials from areas to receive fill or areas that will support structural slabs, footings, or pavement base. Do not perform undercut excavation work until material to be excavated has been cross-sectioned by the Soils Testing Firm or a representative of the Owner and classified as "Unsuitable Material" by the Soils Testing Firm. <u>Removal, drying and recompaction of wet suitable near surface soils will not be considered as undercut</u>. Authorized undercut excavation and replacement will be paid for based on Unit Prices included in the agreement with quantities approved by the Owner’s Representative and the Architect according to contract conditions relative to Changes in the Work. The Soils Testing Firm shall identify unsuitable soil below sub grades depicted on the drawings. Unsuitable soil shall be removed and placed in the on-site spoils area or disposed off-site if required by the Soil Testing Firm.

3.10: Unauthorized Undercut and Replacement: In the event the Contractor inadvertently excavates below sub grades required by the drawings, he shall achieve proper grades by placing and compacting fill in accordance with these specifications or using granular stone fill as approved by the Soils Testing Firm. <u>Unauthorized undercut and replacement</u> shall be done at <u>no additional cost to the Owner</u>.

3.11: Dewatering:

A. Perform earthwork in a manner to prevent surface water and subsurface or groundwater from flowing into excavations, and to prevent water from flooding project site and surrounding areas.

B. Do not allow water to accumulate in excavations. Remove water using dewatering methods that will prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of sub grades and foundations. Provide and maintain pumps, slumps, suction discharge lines and other dewatering system components necessary to convey water away from excavations.

C. Provide and operate pumps or other equipment necessary to drain, keep excavations, pits, trenches, entire subgrade area free of water under any circumstances or contingencies that may arise.

3.12: Settlement Hubs:

A. Settlement caused by new fill must be allowed to stabilize prior to constructing building foundations. Once the design subgrade has been reached, at least six (6) settlement hubs shall be installed by the contractor in the building pad areas where deeper fill has been placed (as determined by the Geotechnical Engineer). The hubs shall consist of a metal pipe or piece of reinforcing steel that is grouted into a hole excavated at least 12 inches below the ground surface. A piece of PVC pipe should be placed on the outside of the hub to protect it. The elevations of the hubs shall be measured at least twice weekly by the project surveyor. This data should be provided to the Geotechnical Engineer for review. Building foundation construction shall not begin until survey data indicates that settlement measured at the hubs has sufficiently stabilized.

3.13: Tolerances:

A. Rough Grading:

1. Bring finished compacted subgrade to within 0.10 feet of required subgrade for finished parking and driveway elevations indicated. See site drawings for typical paving sections required.
2. Bring finished compacted subgrade to within 0.05 feet of required subgrade for finished floor elevation under floor slab. See Architectural drawings for thickness of floor slab and stone base.
3. No fill or cut slopes shall be steeper than 3:1 (3 feet horizontal to 1 foot vertical) unless indicated otherwise on the plans.
4. Berms or slopes steeper than 5:1 (horizontal to vertical) should be benched or stepped prior to placement of fill.

B. Finish Grading:

1. Re-establish required subgrade levels for any areas on the site where settlement, erosion or other grade changes have occurred.
2. Construct finish grade to contours and elevations indicated on the Drawings or to match existing ground planes using a minimum of <u>6 inches of screened topsoil in the Grassed Play Fields, 6 inches in the Multipurpose Fields and 4 inches minimum in all other areas to be seeded, sodded, sprigged or landscaped</u>. (See priorities in 3.2, d. above.)
3. Bring finish grades indicated to within 0.02 feet in all areas and grade to drain water away from structures. Existing finish grades that are disturbed by the Contractor's operations shall be graded smooth to provide surfaces suitable for the proper use of mowing machines.

4. All ditches, swales and fine graded areas shall drain at a minimum 1% slope. No standing water will be allowed on the site outside of designated wetland areas. The Contractor shall protect all areas as necessary to prevent tracks, potholes, or any irregularities that would cause standing water greater than 1/2" deep.
5. Hand raking and fine, smooth, uniform surfaces will be required. No areas will be acceptable if the grade varies more than 1/2" over any 10' straightedge on a uniformly sloped area.
6. Establish a firm compact bed for seeding by lightly hand rolling where necessary.
7. Use of equipment with laser grading technology is recommended for achieving finish grades at the stadium, softball, baseball and multi-purpose fields.

C. All filled surfaces shall be sealed by rolling with a steel drum or pneumatic tire roller at the end of each day to minimize surface infiltration from precipitation.

D. Equipment with excessive fuel or lubricant leaks shall not be used at any time. Repair equipment immediately or remove from the job site.

E. Prohibited work: Stripping of topsoil, cutting or filling, burning of trash, or dumping of materials will not be permitted within the spread of branches of trees to remain.

F. "Warping" of Grades: Grades surrounding trees to remain shall be warped up or down, where possible, between existing grades of root area and new finished grades. Do not disturb existing root systems of trees to remain.

3.14: Cleanup: Leave premises clean and free of debris resulting from this work.

END OF SECTION 312000

SECTION 321216 – ASPHALT PAVING

PART 1 - GENERAL

1.1: Scope:

A. Related work specified elsewhere:
   1. Concrete Paving (Section 321313)

B. Work included in this section:
   1. Proof-rolling of areas to be paved
   2. Placement and compaction of aggregate base course
   3. Placement of bituminous asphalt paving (on site)

C. Specific Work areas:
   1. Aprons/Drives

1.2: Related Documents:

A. All work shall be in accordance with the applicable sections of the "Standard Specifications for Roads and Structures", by the North Carolina Department of Transportation, latest edition, (NCDOT) and NCDOT Superpave HMA/QMS Manual.

B. American Society for Testing and Materials (ASTM).

1.3: Extent:

A. See drawings for full extent of proposed paving.

B. The Contractor will provide any necessary documentation requested by the Town of Garner that indicates compliance with any and all conditions of approval required to complete work within the Town of Garner.

1.4: See NCDOT specifications for temperature and time of year limitations for asphalt paving in North Carolina.

1.5: Submittals:

A. Submit proposed mix designs for review and approval prior to beginning work. Submit two (2) copies of a listing identifying the types and sources of materials used in the asphalt paving.

B. Submit certificates of compliance for stone base course.

C. Materials List - Submit two (2) copies of a listing identifying the types and sources of materials used in the asphalt paving.

D. Laboratory Test Results - Submit two (2) copies of laboratory test reports for in-place construction as specified by the Owner. A minimum of <u>two (2) locations</u> for finished paving shall be tested, proportionately spaced throughout the site or as directed by the Engineer/Landscape Architect. See "Field Quality Control" in this section for frequency of tests on base course.

PART 2 - PRODUCTS

2.1: Stone Aggregate Base Course - Stone shall be NCDOT ABC per Section 520, pages 5-10 through 5-15 and Section 1010, pages10-30 through10-40. The base course stone should be compacted to at least 100 percent of the maximum dry density as determined by the modified Proctor compaction test, AASHTO T-180 as modified by NCDOT.

2.2: Surface and Intermediate Course Asphaltic Concrete- Asphaltic concrete shall be plant mixed bituminous concrete equal to Superpave Types S-9.5B and I-19.0B conforming to Section 610, pages 6-27 through 6-51. Thickness shall be as detailed and noted on the drawings.

2.3: Water - Water must be clean, free of deleterious materials or chemicals that would interfere with proper bonding or smoothness of surface finishes.

PART 3 - EXECUTION

3.1: Layout:

A. All subgrades provided shall be confirmed to be within allowable tolerance of Section 312000 prior to placing any stone base.

B. Concrete curb shall be confirmed at proper finished grade before any placing of stone base course and paving.

C. The Engineer/Landscape Architect shall be notified immediately of any variances from the drawings for finished grades of asphalt paving.

3.2: Weather Limitations - Apply bituminous material only as per NCDOT Section 610-4.

3.3: Install the type of asphalt paving as per the relevant sections of NCDOT Section 610.

3.4: Surface Preparation:

A. Remove all loose material from the compacted sub-base surface immediately before applying prime coats. Use power brooms or blowers supplemented by hand brooms or other acceptable means.

B. Proof-roll prepared sub-base surface using a heavy, rubber-tired roller to check for unstable areas and additional areas needing compaction.

C. Notify the Engineer/Landscape Architect of any unsatisfactory conditions. Do not begin paving work until such conditions have been corrected and areas are ready to receive paving as specified.

3.5: Thickness Tolerances - Set asphalt and stone base thickness to depth indicated on the drawings for area noted, within the following tolerances:

A. Aggregate Base Course: Minimum specified thickness or up to 1/2" plus.

B. Intermediate Course: Minimum specified thickness or up to 1/4" plus.

C. Surface Course: Minimum specified thickness or up to 1/8" plus.

*Note: Pavement thickness outside the specified tolerances will not be accepted without acceptable testing results approved by the soils testing firm and the owner.*

3.6: Tack Coat:

A. Apply to vertical contact surfaces of previously constructed asphalt or concrete and surfaces abutting or projecting into asphalt pavement. Distribute at rate of 0.05 to 0.08 gal. per sq. yd. of surface. Allow to dry until at proper condition to receive paving. Exercise care in applying bituminous materials to avoid smearing of adjoining concrete surfaces. Clean all surfaces. Note: Tack coat is <u>not</u> required over stone base course prior to placement of bituminous concrete.

3.7: Placing Mix:

A. Place asphalt mixture per NCDOT requirements on prepared surface, spread and strike-off. Spread mixture at minimum temperature of 225 deg. F. (107 deg. C). Place inaccessible and small areas by hand. Place each course to required grade, cross-section, and compacted thickness.

3.8: Pavement Placing:

A. Place in strips not less than 10' wide, unless otherwise acceptable to Engineer/Landscape Architect. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Install base or intermediate courses for a particular section before placing final surface course.

3.9: Rolling:

A. Begin rolling when mixture will bear roller weight without excessive displacement. Compact mixture with hot hand tampers or vibrating place compactors in areas inaccessible to rollers.

3.10: Breakdown Rolling:

A. Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling, and repair displaced areas by loosening and filling, if required, with hot material.

3.11: Second Rolling:

A. Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been thoroughly compacted.

3.12: Finish Rolling:

A. Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained maximum density.

3.13: Surface Smoothness - At intervals directed by the Engineer/Landscape Architect, test the finished surface of the asphalt paving for smoothness using a 10' straight edge applied parallel with and at right angles to the centerline of the paved area. Finished surfaces will not be acceptable if they exceed the following tolerances for smoothness:

A. Base Course: 1/4"
B. Intermediate Course: 1/4”
C. Surface Course: 1/8"

A. 1/8”, after 30 minutes elapsed time from flooding on a clear, 55 degree or higher temperature day.

3.15: Field Quality Control:

A. Field inspection, sampling and testing to be performed according to the requirements described in the Supplementary General Conditions or Division 1 Specification.

B. Stone aggregate base course shall be compacted to 100% density of ASTM D698 and AASHTO 180.

C. Frequency of tests on base course: One test every 10,000 sq. ft. per lift.

3.16: Protection:

A. Immediately after placement, protect pavement from mechanical injury until bituminous asphalt has cured or at least 6 hours, whichever is longer.

B. Erect barricades to protect pavement from traffic until mixture has cooled enough not to become marked.

3.17: Cutting and Patching:

A. All walks, paving, and bituminous paved areas cut, removed or otherwise damaged shall be repaired as specified herein.

B. Remove and replace areas that pond water are mixed with foreign materials or are damaged. Saw cut out such areas and fill with fresh, hot asphalt. Compact by rolling to maximum surface density and smoothness.

C. Where necessary to remove existing surfacing for excavation or trenching purposes, the pavement shall be removed for a distance of at least 6 inches beyond the top edge of the excavation or trench, unless otherwise specified.

3.18: Submittals:

A. Submit two (2) copies of a listing identifying the types and sources of materials used in the asphalt paving.

3.19: Pavement Samples:

A. The Owner reserves the right to take samples of the asphalt pavement in the locations, quantities, and manner that he deems necessary to assure compliance with these specifications.

END OF SECTION 321216

# SECTION 32 13 13 - CONCRETE PAVING

## PART 1 - GENERAL

1.1 SCOPE:

A. Work included in this section:

1. Concrete walk paving (light broom finish)
2. Concrete handicapped access ramps
3. Concrete curb and gutter
4. Reinforced Concrete paving (Service, Fire Lanes and Emergency Access Areas)
5. Color additives in concrete paving where indicated (if used)

B. Layout:

1. See details and dimensions on the drawings.
2. Thickness of paving is noted or detailed on the drawings.
3. All edges and lines shall be smooth and continuous with no jogs or form joint breaks visible.

1.2 References - American Society for Testing & Materials (ASTM)

1.3 Codes and Standards: Comply with applicable provisions of ACI 301 “Specifications for Structure Concrete Buildings”, ACI 318, “Building Code Requirements for Reinforced Concrete”, and ACI 347, “Recommended Practice for Concrete Formwork”.

1.4 Testing: Owner’s testing laboratory will perform sampling and testing as indicated in Field Quality Control paragraph. The Contractor shall have an experienced concrete placement representative with good communication (English) skills at each concrete pour in order to address any testing or quality issues such as low slump concrete, air content deficiencies, addition of water, rejection of concrete, etc.

1.5 Field Quality Control: During placement of concrete, the following tests and sampling shall be made:
Sampling: ASTM C 172
Slump: ASTM C 143
Air Content: ASTM C 173
Compressive Strength: ASTM C 39; one specimen tested at seven (7) days, and one specimen tested at twenty-eight (28) days, and one retained for later testing if required.

1.6 Concrete Mixes: Contractor shall employ an acceptable testing laboratory to perform materials evaluation and testing, and to design concrete mixes.

1.7 Color Additives: Where indicated on drawings, mix color additives to concrete mix prior to placement. Submit for review the manufacturer's product data including mixing instructions.

A. Manufacture's Qualifications.

1. Sufficient plant facilities to provide quality and quantity of materials as required without delaying progress of work.

2. Minimum of 10 year's experience in producing iron oxide pigments to be added to concrete.

B. Mock-ups:

1. Construct mock-ups of concrete with pigments for approval by Architect.

2. Approved mock-ups shall become the standard for color, appearance and workmanship.

3. Mock-ups shall not remain as part of the completed work. At Architect's direction, demolish mock-ups and remove debris.

C. Storage:

1. Handle materials in accordance with manufacturer's instructions.

2. Protect materials during handling and mixing to prevent damage or contamination.

PART 2 - PRODUCTS

2.1 Materials:

A. Concrete: Conforming to ASTM C94-73a., standard weight, with minimum compressive strength of 4,000 psi and 3,000 psi at 28 days at locations designated on the plans. When placed, concrete shall have a slump between 3 and 5 inches. (All concrete placed on or above sub-grade shall be 4,000 psi. Concrete used for footings or totally below grade may be 3,000 psi.) Use air-entraining admixture in all concrete, providing not less than 4% nor more than 6% entrained air for concrete exposed to freezing and thawing, and from 2% to 4% for other concrete.

B. Forms:

1. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

a. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. **Do not use notched and bent forms.**

b. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2. Profile shall conform to details and dimensions on the drawing.

3. Steel forms shall be of approved section with a flat surface at the top.

4. Curb & Gutter:

(a) Outside forms shall have a height equal to the full depth of the back of the curb and gutter. The inside forms shall have profile as detailed, and shall be securely fastened to, and supported by, the outside form.

(b) Rigid forms shall be provided for curb returns, except that benders of flexible steel forms may be used for curb returns or walk edges less than 10' radius, or where grade changes occur or the central angle is such that a rigid form cannot be used.

(c) Expansion Joint Filler: Material shall be asphalt-impregnated fiber strips 1/2" thick, unless otherwise shown on the drawings, similar or equal to Celotex "Flexcell", and shall be cut and shaped to the cross-section of the curb or walk.

C. Color additives: Provided by manufacturer whose products are similar or equal to Solomon Colors, PO Box 8288, Springfield, Illinois 62791. Phone (800) 624-0261 / (217) 522-3112. Fax (800) 624-3147/ (217) 522-3145. Web Site www.solomoncolors.com. E-Mail sgs@solomoncolors.com

2.2 Samples:

A. Provide an on-site sample for review and approval by the Architect and Owners' Representative prior to installation of each type of concrete paving.

1. Provide a 5' wide X 20' long section of concrete walk with at least one expansion joint (E/J) and one cut joint (C/J).

2. Provide a 20' long section of curb and gutter with at least one E/J and one C/J.

B. Provide a 20'x20' section of reinforced concrete paving with at least one expansion (control) joint (E/J) and one saw cut (C/J) joint

C. Provide a 5' x 5' section of dark colored concrete for handicap access ramps. Concrete used for these ramp areas may be black, dark brown or dark gray and must meet NC Accessibility requirements for 'contrasting color'.

D. Sample sections shall be used to determine the minimum quality of finishing for all concrete work on site. Provide one sample for each color finish.

2.3 Concrete Pigments

A. Dry Powder Iron Oxide pigments

1. SGS Integral Colors for Ready Mix Concrete

2. Color to be selected by Architect

3. Compliance with ASTM C 979

4. Material is Natural and synthetic, milled, blended iron oxide in dry powder form.

5. Produce uniform and consistent color.

6. Must be permanent, inert, stable to atmospheric conditions, sunfast, weather resistant, alkali resistant, water insoluble, lime proof, and non-bleeding.

B. Liquid Iron Oxide pigments

1. SGS Integral Colors for Ready Mix Concrete

2. Color to be selected by Architect

3. Material is predispersed iron oxide pigments containing high pigment solids in aqueous base liquid.

4. Free of deleterious fillers and extenders.

5. Particle size: 95 to 99 percent minus 325 mesh

6. Specific Gravity: 1.9 to 2.0

PART 3 - EXECUTION

3.1 Preparation of sub-grade:

A. Where dimensions permit, sub-grades shall be proof-rolled with a loaded 20 ton dump truck or pneumatic-tired roller in the presence of the Soils Technician prior to placement of improvements. Any areas found not satisfactory shall be immediately reported to the Architect and repairs made by the Contractor prior to continuing work.

B. Sub-grade shall be maintained in a smooth, compacted condition, in conformity to the required section and established grade until the concrete is placed. The sub-grade shall be in a moist condition when concrete is placed.

C. No concrete shall be placed on a sub-grade that is frozen or muddy.

3.2 Placement of forms:

A. Set forms to alignment and grade conforming to dimensions and grades on the drawings.

B. Forms shall be held rigidly in place by use of stakes placed at intervals not to exceed 48".

C. Clamps, spreaders, and braces shall be used where required to insure rigidity in forms.

D. Forms may not be removed less than two hours after concrete has been placed. Do not allow forms to remain in place more than 24 hours after the concrete has been placed. In no case shall the forms be removed while concrete is plastic or may slump in any direction.

E. Forms shall be cleaned and coated with clear, stainless form oil each time before concrete is placed.

3.3 Concrete Placement:

A. Concrete shall be placed in forms in a manner that prevents concrete splatter on adjacent improvements. In no instance shall the concrete be allowed to free fall from a height greater than 36".

B. Thoroughly consolidate concrete in the forms by tamping and spading so that there are no rock pockets at the forms, and cement mortar entirely covers top surfaces. Concrete may be compacted by means of mechanical vibrators, provided no movement in the forms will occur.

3.4 Joints:

A. Alignment: Expansion and contraction joints shall normally be constructed at right angles to the edge of walks and curbs. Dowels, steel reinforcement bars, and tie-bars shall be installed if indicated by notes or details on the drawings. The Contractor may generally scale the location of joints on the drawings and make slight adjustments as necessary to promote consistency and pattern.

B. Expansion Joint (E/J):

C. Form expansion joints by means of a pre-formed expansion joint filler material cut and shaped to the full depth of the cross-section.

D. Provide expansion joints at the ends of all curb returns and whenever concrete paving abuts the building wall, manholes and other cast-iron frames and structures, and previous concrete pours.

E. Expansion joints are not required between concrete paving and asphalt paving.

F. Provide expansion joints as detailed on the drawings and generally at intervals not exceeding 300 sq. ft. or intervals of 20' separation in any direction unless approved by the Architect or Owners' Representative.

3.5 Contraction Joint (C/J):

A. Sawn (Contraction) joints must be a least ¼ of the thickness of the concrete pavement to promote shrinkage cracking along the joints. For linear sidewalks, the Contractor may choose to construct contraction joints by use of 1/8" thick separators of a section conforming to the cross-section of the walk and curb. Coat separators with a clear, stainless form oil prior to pouring concrete. Separators shall be removed as soon as practical after the concrete has set sufficiently to preserve width and shape of joint. Repair quickly any concrete dislocated by the removal of the separator. After separator plates have been removed, all exposed edges and joints shall be rounded with a proper edging tool.

B. The Contractor shall submit and review the location of contraction joints with the Architect for approval of the pattern prior to installation. For linear walks, the contraction joint spacing shall be approximately 5 feet on center. Contraction joints in large paved areas shall not result in sections exceeding 100 sq. ft. intervals.

3.6 In Service, Fire Lane, Emergency access paving, the maximum contraction joint spacing shall not exceed 15 feet in all directions.

3.7 Finishing:

A. After striking off and consolidating concrete, smooth the exposed surface by screeding and floating to compact the surface and produce a uniform texture.

B. After floating, test surface for trueness with a 10 foot long straightedge. Distribute concrete as required to remove surface irregularities, and refloat repaired areas to provide a continuous smooth finish.

C. Work edges of walk, back top edge of curb, transverse joints and construction joints with an approved edging tool.

D. After completion of floating and when excess moisture and surface sheen has disappeared, install light broom finish by drawing a fine-hair broom across the concrete surface, perpendicular to the line of traffic and install “window pane” finish in all pedestrian areas.

E. Point-up any minor honeycombed areas and replace areas or sections of major honeycombing.

F. Protect the curb and walks from traffic or use for at least 14 days after placement.

G. Top of curb face shall be rounded with an edging tool to a radius of 3" and surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. All surfaces shall be floated and finished as specified for curb face.

H. Immediately after removing forms from any faces that will be visually apparent, the face shall be rubbed with a wood or concrete rubbing block and water until all blemishes, form marks, and tool marks have been removed.

I. Except at severe grade changes or curves, finished surfaces shall generally not vary more than 1/4" over a 10 feet straight edge. Irregularities exceeding this degree of smoothness shall be corrected to the satisfaction of the Architect.

J. All concrete poured shall be of consistent color and appearance throughout the project. All stains must be removed prior to inspection.

K. Contractor shall be responsible to control rinse water run off and prevent pollution.

3.8 Curing & Protection

A. Horizontal concrete surfaces shall be maintained in moist condition for seven days after the pour. This may be accomplished by initial light wetting for the first two days, followed by waterproof covering for the remaining five days. Protect from freezing.

B. An alternate method of curing using an approved curing compound may be used if approved by the Owner's Representative and the Architect in lieu of water curing. Curing compound conforming to ASTM C309 may be applied immediately after trowelling at a rate not to exceed 300 square feet per gallon.

C. Protection:

1. After curing, debris shall be removed and the backfill shall be placed as required.

2. Completed work shall be protected from damage until accepted by the Owner. The Contractor shall repair damaged concrete and clean any discolored concrete to the satisfaction of the Architect. Damaged work shall be removed from the site and reconstructed for the entire length between regularly occurring joints, and not by refinishing the damaged portion only.

3.9 Iron Oxide pigments application:

A. Add pigments to mixer in same order for each batch

B. DO NOT add pigment to mixer as first concrete material. Add liquid pigments to concrete batch after pre-wetted aggregate and before cement addition.

C. Add liquid pigments to concrete batch automatically by use of metering, volumetric, or weight measuring system or manually by weight or volume in accordance with manufacturer's instructions.

D. Recycle liquid pigments while in their container before use to ensure uniformity and proper.

E. Maintain consistent amounts of batch water in each batch

F. DO NOT fog with water or cover surface of colored concrete during initial curing process for a minimum of 48 hours.

3.10 Cleaning

A. Clean concrete of efflorescence in accordance with manufacturer's instructions.

B. Ensure concrete has sufficiently cured before cleaning.

C. Use concrete cleaner approved by pigment manufacturer and Architect. Do NOT use cleaners containing acid.

END OF SECTION 32 13 13

# SECTION 329300 – LANDSCAPING

## PART 1 – GENERAL

1.1: Scope

A. Related Work Specified Elsewhere:

1. Erosion and Sediment Control (Section 311010)

B. Work Included in This Section: Furnish all materials, equipment, and labor for the planting of seed, protection, maintenance, mulching of grass areas, guarantee and replacement; coordination with other trades and related items required to complete the work indicated on the drawings and as specified, including but not limited to:

1. Existing soil preparation & fertilizing, including placement of topsoil
2. Seeding and sodding of grass
3. Seeding and sodding Hybrid Bermuda
4. Maintenance requirements, guarantees and warranties

1.2: Industry Standards:

A. References: Some products and execution are specified in this Section by reference to published specifications or standards of the following (with respective abbreviations used):

The American Society for Testing and Materials (ASTM).
U.S. Dept. of Agriculture (USDA).
N.C. Department of Agriculture (NCDA).

Applicable sections of the Standard Specifications for Roads and Structures, latest edition, by the North Carolina Department of Transportation (NCDOT).

B. Landscape Contractor shall mean a registered "Landscape Contractor" as defined by the General Statutes of North Carolina. Unless proper credentials and evidence of experience can be supplied to the Engineer/Landscape Architect to substantiate equal capabilities, only a Landscape Contractor licensed in North Carolina shall be permitted to perform this work. NOTE: This landscape contracting firm shall have successfully completed five (5) projects of similar size to this project within the past five (5) years.

1. The Landscape Contractor's performance shall be required to conform to the recommendations provided in the most current edition of the NC Landscape Contractors Manual (NCLCM) as approved by the NC Board of Landscape Contractors. Conformance to the NCLCM includes conformance with recommendations of the NC Cooperative Ext. Service publication, Carolina Lawns. In the event that the Contractor believes there is an inconsistency between the NCLCM and requirements of this Contract that could affect the quality of work; it is the Contractor's responsibility to discuss the situation with the Engineer/Landscape Architect and Owner's Representative.

1.3: Submittals:

A. Guarantees: Submit guarantee in writing (in duplicate) stating terms of guarantee, name of Landscape Contractor, name of Owner, name of Project, location, and dates of guarantee.

B. Project Schedule: Prior to 30 calendar days of beginning landscaping work as defined herein, submit a proposed time schedule indicating estimated dates for beginning and completing the following operations:

1. Submittals.
2. Delivery of materials.
3. Preparation of areas to receive grassing, seeding and sodding.
4. Seeding and sodding.

C. Maintenance: Prior to 14 calendar days from beginning Seeding and Sodding operations; submit to the Engineer/Landscape Architect, with copy to the Owner, a typewritten outline of maintenance procedures to be followed by the Landscape Contractor during establishment of the project landscaping. This Contractor will maintain all of the landscape work prior to Substantial Completion (Initial Acceptance by the Owner) including maintenance of fields and grounds as indicated on the drawings. The outline shall conform to the requirements of the Contract and recommendations provided in the most current edition of the NC Landscape Contractors Manual as approved by the NC Board of Landscape Contractors.

D. Materials:

1. Manufacturer's names and data relating to fertilizers and additives shall be submitted for approval.

E. Certificates of Inspection: The Landscape Contractor shall be responsible for all certificates of inspection of seeding materials that may be required by federal, state, or other authorities to accompany shipments of landscape items.

F. Sub-Contractors: All sub-contractors must be approved by the Engineer/Landscape Architect in writing.

G. Maintenance Schedule during Guarantee Period: Submit to the Owner, with copy to Engineer/Landscape Architect, typewritten instructions outlining procedures to be established <u>by the Owner</u> for maintenance of grassing work during the guarantee period. Submit to Engineer/Landscape Architect for approval 30 days prior to Substantial Completion.

PART 2 - PRODUCTS

2.1: Materials:

A. Fertilizer: Shall be <u>slow release</u> commercial fertilizer delivered to the site in unopened original containers each bearing the manufacturer's guaranteed analysis. Any fertilizer that becomes caked or otherwise damaged shall not be accepted. Fertilizer shall contain a 10-10-10 ratio of nitrogen, phosphate, and potash, unless otherwise determined by soil test and analysis.

B. Lime: Lime shall be dolomitic ground limestone meeting NCDA requirements for agricultural limestone.

(1) Seeded areas shall be mulched with clean grain straw, free of pests and blight and tacked with asphalt emulsion, type RS or CRS, at the rate of 10 gal. per 1,000 S.F.

C. Water: Water to be used in this work shall be furnished by the Landscape Contractor unless otherwise noted. Equipment for watering the seed and sod~~;~~ including hoses as required, shall be furnished by the Landscape Contractor.

D. Triple Screened Topsoil: Triple screened topsoil furnished by the Landscape Contractor to meet project requirements shall be a natural, fertile, friable soil, possessing characteristics of representative productive soils in the vicinity. “Triple Screened Topsoil” has typically been sifted through three 1/2” x 1/2” sized screens and contains no rocks or debris that would hinder landscape operations.

**NOTE: This Contractor will be responsible for cleaning, screening and amending the topsoil on site for his use. Debris or other objects that would hinder landscape operations will not be acceptable in the topsoil.**

E. Materials:

1. Grass seed shall be improved turf type Bermuda, "Jackpot" "Savannah" or other variety approved by the Owner's Representative. All seed shall be certified seed meeting all standards of purity as required by the United States Department of Agriculture.

2. Sod shall be <u>T-10 Hybrid Bermuda or approved equal.</u> Provide machine cut, strongly rooted, certified turf grass sod, not less than 2 years old, free of weeds and undesirable native grasses and stripped not more than 24 hours before laying. Sod pad size shall be uniform thickness of 5/8", plus or minus 1/4", measured at the time of cutting and excluding top growth and thatch. Provide in suppliers standard size of uniform length and width with maximum allowable deviation of plus or minus 1/2" in width and 5/8" in length. Sod pad should be able to support its own weight and retain its size and shape when suspended vertically from a firm grasp on the upper 10% of the sod pad.

F. Pre-Emergent Herbicide: Herbicide shall be Ronstar-G as manufactured by Rhone-Poulanc Corporation or approved equal.

G. Herbicide: Herbicide shall be Round-up by Monsanto or approved equal.

PART 3 - EXECUTION

3.1: Existing Conditions:

A. Experience: Employ only experienced personnel who are familiar with the required work. Provide adequate Supervision by a qualified foreman.

B. Installation time: Install materials only during normal planting seasons for each type of landscape work required. Correlate planting with specified maintenance periods to provide maintenance until acceptance by the Owner.

C. Subgrade elevations: Excavation, filling and grading required to establish elevations shown on the drawings are specified under other sections of these specifications. Landscape Contractor shall verify finish grade elevations and notify the Engineer/Landscape Architect in writing of any discrepancies prior to beginning work.

D. Construction Below Ground or Overhead: It is not contemplated that planting shall occur where the depth of soil over underground construction, obstructions or rock is insufficient to accommodate the roots or where pockets in rock or impervious soil will require drainage. Where such conditions are encountered in excavation of planting areas and where the stone, boulders, or other obstruction cannot be broken and removed by hand methods in the course of digging plant pits of the usual size, the Engineer/Landscape Architect shall be notified so that this material may be removed by the Owner, or the plant material relocated to a more favorable location. Removal of rock or other underground obstructions, relocation of construction, and provisions of drainage for planting areas shall be done only as approved by the Engineer/Landscape Architect and the Owner.

3.2: Preparation of Areas to be Grassed or Sodded Soil Mix.

A. General:

1. Preparation shall not start until after all other site work has been completed and approved by the Engineer/Landscape Architect within the areas to be seeded or sodded.

2. The Contractor shall confirm to the Engineer/Landscape Architect in writing that all surfaces to receive Lawn Grassing are at the proper finish grade and have been “policed” to remove all rocks, trash and debris from the surface prior to beginning soil preparation.

B. Areas to be Grassed (Lawn):

1. Loosen soil thoroughly to a depth of 6 inches, or if heavy clay or overly compacted soils are present, sub-soil plow to 12" depth until tillage is suitable for subsequent operations. **Remove all rocks greater than 1" diameter from prepared soil surface prior to seeding.** Work in the following soil additives:

| | |
|---|---|
| Lime - | 120 lbs./1000 sq. ft. |
| Fertilizer - | 35 lbs./1000 sq. ft. (Formula 10-10-10) |
| 20% Super Phosphate | 25 lbs/1000 sq. ft. |

2. Grade lawn to a smooth, even surface with a loose, uniformly fine texture. Roll and rake lawn areas to remove ridges and fill depressions as required to meet finished grades. Limit fine grading to areas which can be seeded and/or planted within the near future.

C. Areas to be Sodded:

1. Loosen soil thoroughly to a depth of 6 inches, until tillage is suitable for subsequent operations**. No rocks are allowed in surface soils to receive sod.** Work in the following soil additives:

| | |
|---|---|
| Lime: | 100 lbs./1000 sq. ft. |
| Fertilizer: | 20 lbs/1000 sq. ft. |
| Superphosphates: | 10 lbs/100 sq. ft. |

2. Fine grade lawn areas to a smooth, even surface with a loose, uniformly fine texture. Roll and rake to remove ridges and fill depressions as required. Limit fine grading to areas which can be sodded within the near future. Moisten lawn area before sodding if soil is dry.

D. Mix the following soil additives to topsoil stored on-site or approved subsoil for seeding:

1. Decomposed organic matter - use sufficient amount to raise the organic content to 5% minimum by volume.
2. Use 0.1 pounds/cu. ft., 10-10-10 fertilizer.
3. Use 0.4 pounds/cu. ft. dolomitic lime meeting North Carolina Department of Agriculture standards for fineness and purity.

E. Dispose of subsoil removed from seeding operations.

3.3: Seeding and Sodding:

A. Seeding:

1. Grassing Season: All permanent grassing shall be installed according to the N.C. E. & S. Manual or as approved by the Engineer/Landscape Architect. Temporary grassing will be planted according to Section 311010.

2. Prepare seed bed by carefully raking out all debris and provide positive drainage away from plant beds and buildings.

3. Final grading and starter fertilizer: Check slope, remove all foreign materials and stones larger than **1/2 inch in the surface of the prepared soil**. Level soil and roll with heavy (250-300 lbs) roller. Keep soil damp, not dry or wet, when it is worked. Alternately rake and roll area until footprints cannot be seen readily or they are less than 1/4 inch deep.

4. Apply starter fertilizer at a rate that will provide 1 to 1-1/2 lbs. of actual nitrogen/1000 sq.ft. Rake starter fertilizers into soil surface about 1 inch deep and proceed with grass seeding.

5. Sow grassed areas evenly with a mechanical spreader to produce a uniform stand of grass.

6. Seed shall be 'scratched in' with a garden rake or rolled with a light roller or cultipacker to firm the seed in the soil. The method of seeding may be varied at the discretion of the Landscape Contractor on his own responsibility to establish

a smooth, uniform grassed lawn. In normal season, the lawn grass seed shall be sown uniformly at the rate of three (3) lbs per 1000 sf of "Savannah" variety hulled Hybrid Bermuda. Sow only when moisture content of the soil is suitable for sowing grass seed. Keep soil in moist condition until seeds have germinated.

7. Mulch: All grassed areas shall be mulched with clean grain straw as specified. Straw mulch shall be tacked with emulsified asphalt (thinned with water) at a rate of 150 gallons per ton of straw.

8. Establishment and Maintenance: Water, mow, and maintain until an acceptable stand is achieved.

   a. Irrigation: From time of seeding to Substantial Completion, the Contractor **shall** keep maturing grass irrigated on a regular basis. Irrigation shall occur a minimum of once each day until two (2) weeks after date of initial seeding. Thereafter, irrigation shall occur a minimum of once a week.

   b. At no time shall seeded permanent turf be allowed to grow over 4 inches in height. Throughout this period, the target mowing height shall be 1.5-2 inches. At no time shall more than 50% of the turf height be removed in any three-day period by mowing or other maintenance activity.

   c. Seeded permanent turf shall be fertilized according to the monthly application rates recommended in Carolina Lawns for common Bermuda grass or at reduced rates if instructed by the Engineer/Landscape Architect.

   d. Weed control shall be provided as necessary to prevent the establishment or proliferation of a weed species and to achieve acceptable turf at time of Initial Acceptance.

B. Sodding:

   a. Sodding Season: Anytime during the year when freezing conditions do not exist and as approved in advance by the Engineer/Landscape Architect and Owner.

   b. Lay sod to form solid, uniform mass with tightly fitted joints. "Butt" ends and sides of sod strips. Do not overlap sod strips. Stagger strips to offset joints in adjacent courses. Lay sod strips across slopes and perpendicular to drainage flow. Tamp or roll lightly to ensure contact with subgrade.

   c. Secure with pegs or staples at spacing recommended by the sod grower and supplier and as approved by the Engineer/Landscape Architect and Owner.

   d. Water sod with fine spray immediately after planting. Water daily during first two weeks of establishment to maintain soil to depth of 4".

   e. At no time shall sodded turf be allowed to grow over 3 inches in height. Throughout this period, the target mowing height shall be 1.5 inches. At no time shall more than 50% of the turf height be removed in any three-day period by mowing or other maintenance activity.

f. Sodded turf shall be fertilized according to the monthly application rates recommended in Carolina Lawns for the utilized grass or at reduced rate if instructed by the Engineer/Landscape Architect.

g. Weed control shall be provided as necessary to prevent the establishment or proliferation of a weed species and to achieve acceptable turf at time of Initial Acceptance.

3.4: Mulching and Protection:

A. Mulch seeded areas with straw as specified and tack with water emulsified asphalt at a rate of 150 gallons per ton of straw or other acceptable means.

B. Protect newly seeded areas from unnecessary pedestrian traffic for three (3) weeks minimum.

3.5: Mowing: The Landscape Contractor shall water, fertilize, mow, reseed, roll, re-grade, re-sprig, replant/patch bare spots and maintain all lawn areas in conformance with the NC Landscape Contractors Manual until an acceptable stand is achieved and the areas are accepted by the Owner for maintenance.

3.6: Maintenance:

A. Maintain work of this section from time of installation until Substantial Completion. Maintenance shall include: at minimum bi-weekly watering of seeded and sodded areas, lawn mowing; repairs to turf.

B. At the end of the guarantee period, and prior to Final Acceptance, all seeded areas shall be free from weeds.

3.7: Clean-up and Completion:

A. During landscape work, keep pavements clean and work area in an orderly condition.

B. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged landscape work as directed.

C. Upon completion of work, remove from the site all equipment and other articles used. All excess soil, stones and debris shall be removed and legally disposed of. All work areas shall be left in a clean and neat condition. Final Acceptance will not be given unless all work areas are clean.

D. All damage to existing construction caused by landscaping operations shall be repaired to the satisfaction of the Owner, at the Landscape Contractor's expense.

3.8: Beneficial Occupancy Inspection and Acceptance by the Owner:

A. Following receipt of a written request submitted by the Contractor with his list of any items yet to be completed and the reasons associated with any delays, the Engineer/Landscape Architect will schedule an inspection of the work to determine acceptability. A list of deficiencies will be made according to the conditions of the Contract.

B. All grassed areas shall be freshly mown within 48 hours before the Substantial Completion Inspection. Lawn areas shall be healthy, of uniform color and exhibiting signs of good growth. A minimum of 95% of the specified seeding area shall be covered in established turf possessing both stolons (i.e. runners) and rhizomes. There shall be no bare areas greater than 4 sq. ft. or 1.5 ft. in any dimension. Lawn areas shall be 100% free of noxious and perennial weeds and relatively free of annual weeds.

C. Sodded lawn (if any) shall be freshly mown within 48 hours prior to the Substantial Completion Inspection. Turf shall be healthy, of uniform color and exhibiting good growth. A minimum of 100% of the sodded turf area shall be covered in sod that has been installed for a minimum four weeks. Sodded turf shall be 100% free of all weeds.

D. When inspected landscape work does not comply with requirements, replace rejected work and continue specified maintenance until reinspected by Engineer/Landscape Engineer/Landscape Architect and found to be acceptable.

E. Final Completion by the Contractor shall be established upon completion of all landscape replacements and repairs to the landscape as identified during the Substantial Completion Inspection.

3.9: Guaranty and Replacement:

A. Seeding (grassing):

1. If a satisfactory stand of grass has been produced at the time of Substantial Completion (Initial Acceptance); the lawn shall be guaranteed for a period of sixty (60) calendar days. If renovation and / or reseeding is required at the end of the guarantee period, this work shall be done in conformance with the requirements of section 3.8.

2. If a satisfactory stand of grass has not been produced at the time of Substantial Completion, all bare areas shall be immediately sodded per the requirements of this section and guaranteed for a period of sixty (60) calendar days after a successful inspection by the Owner.

B. Sodded Lawn:

1. If a satisfactory sodded lawn and athletic turf has been produced at the time of Substantial Completion (Initial Acceptance), the turf shall be guaranteed for a period of sixty (60) calendar days. If renovation and/or re-sodding is required at the end of the guarantee period, this work shall be done in conformance with the requirements of this section.

2. If a satisfactory sodded turf has not been produced at the time of Substantial Completion (Initial Acceptance), all unacceptable areas will be re-sodded according to the requirements of this section. Upon completion of these repairs, the turf shall be guaranteed as in paragraph (1) above.

END OF SECTION 329300

# SECTION 331100 – WATER DISTRIBUTION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

B. City of Raleigh Standards.

C. City of Raleigh details and Public Utilities Handbook dated January 21, 2014 (or latest version).

### 1.2 SUMMARY

A. This Section includes water-distribution piping and related components outside the building

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

### 1.3 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

### 1.4 ACTION SUBMITTALS

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

B. Shop Drawings: Provide shop drawing for each type of product and components.

### 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports and disinfection reports per City of Raleigh requirements.

B. Record drawings at project closeout of installed water distribution piping and products.

### 1.4 CLOSEOUT SUBMITTALS

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

## 1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of the City of Raleigh. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction (Wake County Public School System and City of Raleigh) for potable-water-service piping, including materials, installation, testing, and disinfection.

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

C. NSF Compliance:

1. Comply with NSF 14 for plastic potable-water-service piping.
2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

## 1.7 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify Engineer no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Engineer's written permission.

## 1.8 COORDINATION

A. Coordinate connection to water main with the City of Raleigh.

# PART 2 - PRODUCTS

## 2.1 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.
3. Cement-mortar lining in accordance with AWWA C104.
4. Shall comply with City of Raleigh Standards

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.
3. Shall comply with City of Raleigh Standards.

## 2.2 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Nonrising-Stem, Resilient-Seated Gate Valves:

   a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.

      1) Standard: AWWA C509.

2) Minimum Pressure Rating: 200 psig.
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

B. UL/FMG, Cast-Iron Gate Valves

1. UL/FMG, Nonrising-Stem Gate Valves:

a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig.
3) End Connections: Flanged.

## 2.3 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies: sleeve and valve compatible with drilling machine.

1. Standard: MSS SP-60.
2. Tapping Sleeve: Ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
3. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.
4. In accordance with City of Raleigh requirements.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel diameter in accordance with City of Raleigh requirements.

1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

## 2.4 PVC PIPE AND FITTINGS

A. PVC, Schedule 40 Pipe: ASTM D 1785.

1. PVC, Schedule 40 Socket Fittings: ASTM D 2466.

B. PVC, SDR 21 Pipe: ASTM D 2241.

1. PVC, SDR Socket Fittings: ASTM D 2241.

2.5 TAPPING SADDLE

A. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.

B. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

C. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel in diameter in accordance with City of Raleigh requirements.

1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.6 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. In accordance with City of Raleigh requirements.
2. Standard: ASSE 1013 or AWWA C511.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Size: 6-inch.
6. Body: in accordance with City of Raleigh requirements.
7. End Connections: in accordance with City of Raleigh requirements.
8. Configuration: Designed for horizontal flow.
9. Accessories:

a. Valves: OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Double-Check Backflow-Prevention Assemblies:

1. In accordance with City of Raleigh requirements.
2. Standard: ASSE 1015 or AWWA C510.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Size: 2-inch.
6. Body: in accordance with City of Raleigh requirements.
7. End Connections: in accordance with City of Raleigh requirements.
8. Configuration: Designed for horizontal flow.

9. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

2.7 PROTECTIVE ENCLOSURES

A. Freeze-Protection Enclosures:

1. Description: Insulated enclosure designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of 40 deg F when external temperatures reach as low as minus 34 deg F.

a. Standard: ASSE 1060 and in accordance with City of Raleigh requirements.
b. Class I: For equipment or devices other than pressure or atmospheric vacuum breakers.
c. Class I-V: For pressure or atmospheric vacuum breaker equipment or devices. Include drain opening in housing.

1) Housing: in accordance with City of Raleigh requirements.

a) Size: Of dimensions indicated, but not less than those required for access and service of protected unit.
b) Drain opening for units with drain connection.
c) Access doors with locking devices.
d) Insulation inside housing.
e) Anchoring devices for attaching housing to concrete base.

2) Electric heater with self-limiting temperature control.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 5000 “Utility Trenches” (latest version) provided by the City of Raleigh for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground water-service piping NPS 3/4 to NPS 3 shall be the following:

1. PVC, Schedule 40 pipe socket fittings; and solvent-cemented joints.
2. SDR fittings shall be in accordance with manufacturer's installation recommendations.

F. Underground water-line piping NPS 4 to NPS 8 shall be the following:

1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed or mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.
SDR fittings shall be in accordance with manufacturer's installation recommendations.

G. Water Meter Box Water-Service Piping NPS 3/4 to NPS 2 shall be the same as underground water-service piping.

H. Aboveground water-service piping NPS 4 to NPS 8 shall be same the same as underground water-line piping.

3.3 VALVE APPLICATIONS

A. General Application: Use threaded- or flanged-end valves for installation in vaults. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

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

1. Underground Valves, NPS 3 and Larger: AWWA, cast-iron, nonrising-stem, resilient-seated gate valves with valve box.
2. Use the following for valves in vaults and aboveground:

a. Gate Valves, NPS 2 and Smaller: Bronze, rising stem.

3.4 PIPING INSTALLATION

A. Water-Main Connection: Tap water main according to City of Raleigh requirements and of size and in location indicated.

B. Make connections larger than NPS 2 with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box

C. Make connections NPS 2 and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by City of Raleigh standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

D. Comply with NFPA 24 for fire-service-main piping materials and installation.

E. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

F. Bury piping with depth of cover over top at least 36 inches.

G. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

H. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

I. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

## 3.5 JOINT CONSTRUCTION

A. Make pipe joints according to the following:

1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
2. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.

## 3.6 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.

3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.7 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.8 WATER METER INSTALLATION

A. Water meters will be provided and installed by the City of Raleigh.

3.9 ROUGHING-IN FOR WATER METERS

A. Rough-in piping and specialties for water meter installation according to City of Raleigh requirements.

3.10 WATER METER BOX INSTALLATION

A. Install water meter boxes as shown on the construction drawings and in accordance with City of Raleigh requirements.

3.11 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

E. Install in accordance with City of Raleigh requirements.

## 3.12 PROTECTIVE ENCLOSURE INSTALLATION

A. Install concrete base level and with top approximately 2 inches above grade.

B. Install protective enclosure over valves and equipment.

C. Anchor protective enclosure to concrete base.

D. Install in accordance with City of Raleigh requirements.

## 3.13 FIELD QUALITY CONTROL

A. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

B. Prepare reports of testing activities.

## 3.14 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping.

## 3.15 CLEANING

A. Clean and disinfect water-distribution piping as follows:

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

a. Fill system or part of system with water/chlorine solution containing at least 100 ppm of chlorine; isolate and allow to stand for 24 hours.
b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.

c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.

d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

C. All testing, reports, and certifications of the water distribution shall comply with City of Raleigh standards.

3.16 Water Distribution Certification:

A. This Contractor shall secure the services of a NC Registered Professional Land Surveyor (PLS) to survey and certify the as-built Water distribution system installation. The certification shall be done in the following steps:

1. After all water lines are in place, the PLS shall survey the locations of all pipes and appurtenances including pipe sizes are as required on the plans and meet the standards of these specifications. Any pipe sizes or areas that do not meet these standards MUST be removed and reinstalled to meet these standards.

2. As soon as finished grades are established, and final appurtenances are installed, the PLS shall survey the elevations of these items as required on the plans and meet the standards of these specifications.

B. Have the Professional Land Surveyor complete the as-built survey and certification as described above.

C. Submit PLS certified surveys to the Engineer/Landscape Architect for total system certification of the water distribution system as part of the project to the Town of Wake Forest (City of Raleigh).

D. The Contractor is responsible for submitting the certification package to the Town of Wake Forest (City of Raleigh) for the complete water distribution system. This includes but not limited to any certifications in order to close out any permits

END OF SECTION 331100

# SECTION 33 31 11 - SANITARY SEWER SYSTEM

## PART 1 GENERAL

### 1.01 SECTION INCLUDES

A. Work under this section includes, but is not limited to, piping, manholes, diversion structures, valves, and appurtenances for a complete sanitary sewer collection system.

### 1.02 RELATED SECTIONS

A. The following Sections have work that is directly related to this Section. This does not relieve the Contractor of his responsibility of proper coordination of all the work:
1. Section 01 35 13 Specific Project Requirements
2. Section 31 23 33 Trenching for Utilities

### 1.03 REFERENCES

A. Publications are referred to in the text by basic designation only.
1. American Society for Testing and Materials (ASTM)

a. A126 Gray Iron Castings and Valves, Flanges and Pipe Fittings.
b. B117 Operating Salt Spray (Fog) Apparatus
c. C33 Concrete Aggregates
d. C76 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
e. C150 Portland Cement
f. C361 Reinforced Concrete Low-Head Pressure Pipe.
g. C443 Flexible Watertight Joints for Precast Manhole Sections
h. C478 Precast Reinforced Concrete Manhole Sections
i. C497 Standard Methods Testing Concrete Pipe, Manhole Sections or Tile
j. C618 Coal Fly Ash and Raw or Calcined natural Possolan for Use as a Mineral Admixture in Portland Cement Concrete
k. C655 Reinforced Concret D-Load Culvert, Storm Drain and Sewer Pipe
l. C822 Definition of Terms Related to Concrete Pipe and Related Products
m. C890 Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
n. C923 Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
o. C1103 Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
p. C1131 Least Cost (Life Cycle) Analysis of Concrete Culvert, Storm Sewer, and Sanitary Sewer Systems
q. C1244 Test Method for Concrete Sewer Manholes by the Negative Air Pressure
r. C1619 Elastomeric Seals for Joining Concrete Structures
s. D638 Tensile Properties of Plastics
t. D714 Evaluating Degree of Blistering of Paints
u. D1248 Polyethylene Plastics Molding and Extrusion Materials
v. D1784 Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
w. D2241 Poly(Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
x. D2321 Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe
y. D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

z. D2794 Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
aa. D2924 Standard Test Method for External Pressure Resistance of Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pipe
bb. D2996 Filament Wound Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pipe
cc. D2997 Centrifugally Cast Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Pipe
dd. D3034 Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ee. D3139 Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ff. D3262 "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.
gg. D3350 Polyethylene Plastics Pipe and Fittings Materials
hh. D3567 Determining Dimensions of Fiberglass (Glass Reinforced Thermosetting Resin) Pipe and Fittings
ii. D3681 Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition
jj. D3839 Underground Installation of "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Pipe
kk. D4060 Abrasion Resistance of Organic Coatings by the Taber Abraser
ll. D4161 "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
mm. D4541 Pull-Off Strength of Coatings Using Portable Adhesion Testers
nn. D4258 Surface Cleaning Concrete for Coating
oo. D4259 Abrading Concrete
pp. E96 Water Vapor Transmission of Materials
qq. F477 Elastomeric Seals (Gaskets) for Joining Plastic Pipe
rr. F1417 Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
ss. G95 Cathodic Disbondment Test of Pipeline Coatings
tt. D6783 Standard specification for polymer concrete pipe.
uu. C579 Standard test methods for compressive strength of chemical-resistant mortars, grouts, monolithic surfacings, and polymer concrete.
vv. A648 - Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Pipe
ww. A569 – Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality
xx. A1011 – Standard Specification for Steel, Sheets and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
yy. A1011 – Standard Specification for Steel, Sheets and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
zz. A611 Grades C or D - Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Structural Quality
aaa. A635 Grades 1012 through 1020 – Standard Specification for Steel, Sheet, and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled
bbb. A659 - Standard Specification for Steel, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality
ccc. A1018 – Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability

ddd. C969 Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
eee. C990 Standard specification for joints for concrete pipe and manholes using flexible joint sealant
fff. C1417 Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design
ggg. C1479 Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
hhh. D6793 Standard Specification for Polymer Concrete Pipe

2. American Water Works Association (AWWA)
   a. C104 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
   b. C110 Ductile-Iron and Gray-Iron Fittings, 3 inch through 48 inch, for Water and Other Liquids
   c. C151 Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
   d. C153 Ductile-Iron Compact Fittings, 3 inch through 16 inch, for Water and Other Liquids
   e. C504 Rubber-Seated Butterfly Valves
   f. C508 Swing-Check Valves for Waterworks Service, 2 inch Through 24 inch NPS
   g. C512 Air-Release, Air / Vacuum, and Combination Air Valves for Waterworks Service
   h. C550 Protective Epoxy Interior Coatings for Valves and Hydrants
   i. C600 Standard for Installation of Ductile Iron Water Mains and Their Appurtenances
   j. C900 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 inch through 60 inch.
   k. C950 Standard for Fiberglass Pipe
   l. M23 PVC Pipe - Design Installation
   m. M41 Ductile Iron Pipe and Fittings
   n. M45 Fiberglass Pipe Design
3. National Sanitation Foundation (NSF) Standards
   a. 14 Plastic Piping Components and Related Materials
4. UNI-BELL Plastic Pipe Association (UNI)
   a. B-5 Recommended Practice for the Installation of Polyvinyl Chloride (PVC) Sewer Pipe
   b. B-6 Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe
5. Ductile Iron Pipe Research Association (DIPRA)
   a. 8-08/5M Design of Ductile Iron Pipe
6. Reinforced Concrete Pipe
   a. American Concrete Pipe Association (ACPA) Design Data 9 Standard Installations and Bedding Factors for the Indirect Design Method.
7. American Association of State Highway and Transportation Officials (AASHTO)
8. American Concrete Institute
   a. 440.1R-15 Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRP) Bars
   b. 548.6R-96 Polymer Concrete-Structural Applications State-of- the-Art Report

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00, Submittal Procedures:
   1. Affidavit of Compliance: Affidavit shall attest that supplied products conform to the referenced standard and this specification and that tests set forth in each applicable

referenced publication have been performed and that test requirements have been met. Submit for each of the following materials:

a. Pipe
   1) All pipe used on Project
   2) All pipe coatings or liners
b. Pre-cast concrete manholes
   1) The precast manufacturer shall provide detailed design calculations for each configuration (standard, T-base, etc.), which shall include calculations for wall stresses, flotation, depth, reinforcement, and all other criteria necessary for a complete design.
c. Valves
   1) All valves used on Project

2. Catalog Data and Calculations: Submit manufacturer's standard drawings or catalog cuts and calculations for pipe pressure/thickness class, concrete reinforcement and stiffness class for the appropriate type pipe based on the Drawings and Specifications for the following. Clearly indicate material to be furnished for the Project including options to be provided and indicate if a greater pipe pressure/thickness class, concrete reinforcment or pipe stiffness class will be necessary based on the manufacturer's calculations.
   a. Pipe
      1) All pipe used on Project
      2) All pipe coating or liners

   b. Pre-cast Concrete Manholes and the following appurtenances:
      1) Pipe connectors
      2) Joint material
      3) Castings
      4) Interior Coating System
   c. Service saddles
   d. Valves
      1) All valves used on Project
3. Reports:
   a. Field test report for each section of pipe for the following:
      1) Pressure test for force mains.
      2) Low-pressure air test for gravity mains.
      3) Vacuum test for manholes.
      4) Deflection test for gravity mains.
4. Operation and Maintenance Instructions: Submit complete operation and maintenance manual for the following:
   a. Valves.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Provide a rope sling when handling the pipe. Lifting of the pipe shall be done in a vertical plane. Under no conditions shall the sling be allowed to pass through the pipe unless adequate measures are taken to prevent damage to both tongue and groove ends.

B. Deliver pipe in the field as near as practicable to the place where it is to be installed. Distribute pipe along the side of the trench opposite to the spoil bank. Where necessary to move the pipe longitudinally along the trench, it shall be done in such a manner as not to injure the pipe or coating.

C. Shield PVC pipe and fittings stored on site from the sun's ultraviolet rays by suitable cover, or indoor storage.

PART 2 PRODUCTS

2.01 DUCTILE-IRON PIPE

A. Pipe and fittings shall conform to the following requirements:
   1. Size shall be as indicated on the Drawings.
   2. Minimum pipe pressure class shall be 350 for pipes 6-inch to 12-inch diameter, and a minimum pressure class 250 for pipes 14-inch and larger.
   3. Suitable for a system working pressure of 250 psi minimum for gravity sewer, 150 psi for force mains.
   4. Pipe shall be supplied in nominal lengths of 18 or 20 feet.
   5. Pipe lining:
      a. Less than 12-inches: Cement-mortar lined with seal coat in accordance with AWWA C104
      b. 12-inch and larger: Interior of pipes and fittings shall be lined with PROTECTO 401 ceramic epoxy as described in paragraph in this section.
   6. Pipe pressure/thickness class shall be suitable for the type laying condition as provided in Section 31 23 33, Trenching for Utilities, and at the depth indicated on the Drawings. The proper pressure/thickness class shall be at a minimum as shown on the Contract Drawings. Pipe manufacturer to verify pipe selection, and document to Engineer, prior to ordering and manufacture of pipe.
   7. Pipe class shall not transition between manholes and shall be the highest pressure/thickness class required for that reach with exception to sections between manholes including jacking pipe as indicated on the Drawings.
   8. Ductile Iron may be used for gravity sewers and force mains.

B. Ductile-iron pipe for below ground service shall have push-on or mechanical joints, unless noted otherwise on the Drawings, conforming to AWWA C150 and C151, and to the following requirements:
   1. Provide mechanical joint fittings for push-on or mechanical joint pipe, unless noted otherwise on the Drawings.

C. Ductile-iron pipe for above ground service shall have flanged joints, unless noted otherwise on the Drawings, and conform to AWWA C115.
   1. Pipes to be painted shall have only a shop primer on the outside by the manufacturer. Verify that proposed manufacturer’s primer is compatible with the proposed paint system.

D. Fittings for ductile-iron pipe shall conform to AWWA C110, or C153 and to the following requirements:
   1. Joint type shall be as specified above for the supplied ductile-iron pipe.
   2. Fittings shall be made of ductile-iron.

E. Ductile iron pipe on piers shall have Mech-Lok™ rigid restrained joint by US Pipe or approved equal.

F. Special Pipe Joints
   1. River Crossing (Ball Joint)
      a. Boltless
      b. Bolted

G. Restrained Joints:
   1. Provide restrained joint pipe at fittings and valves where indicated on the Drawings. Length of restrained pipe shall be as shown. Restrained joints shall be Flex Ring and Lok-Ring (American), TR Flex (U.S. Pipe) or approved equal.

2. Restrained joint pipe and fittings shall meet all AWWA standards and other requirements as specified above for standard ductile iron pipe and fittings unless addressed herein.
3. Field made joints are allowable but should be avoided where possible. Careful planning to locate field cuts in standard pipe sections is preferred. For field made joints in restrained piping, use field weldments or wedge restraint glands or approved equal. Gasket type field made joints will not be allowed.
4. Restrained joint fittings shall be provided by the restrained joint pipe manufacturer where located within restrained joint pipe sections. Fittings shall be of the same model and type as the pipe supplied from the pipe manufacturer.
5. Restrained joint fittings may be push-on joint type.
6. Megalugs, Series 1100, as manufactured by EBAA Iron Sales or approved equal shall be allowable for restraint where fittings or valves are not available with restrained joints.
7. Where additional fittings/valves are required and not shown on Drawings, consult with Engineer for length of restrained joint pipe necessary each side of fittings/valve prior to installation of pipe/fitting.
8. Contractor shall develop a field layout schedule and drawing(s) for restrained joint pipe installations that are to be submitted for approval as outlined in Section 01 33 00, Submittal Procedures.

2.02 DUCTILE IRON PIPE LINER

A. General
   1. The interior wall of ductile iron sewer pipe and fittings 12" and larger in diameter shall be protected by the Protecto 401 Ceramic Epoxy liner or equal.
   2. The lining shall meet the manufacturer's recommendations and the following requirements as a minimum.
   3. The liner manufacturer shall have a minimum of ten (10) years of successful experience and be able to demonstrate successful performance on comparable projects.

B. Lining Material
   1. The material shall be an amine cured novalac epoxy containing at least 20% by volume of ceramic quartz pigment.
   2. Permeability rating of 0.00 when tested according to Method A of ASTM E-96, Procedure A with a test duration of 30 days.
   3. The following tests must be run on coupons from factory lined ductile iron pipe:
      a. ASTM B-117 Salt Spray (scribed panel) – Results to equal 0.0 undercutting after two years.
      b. ASTM G-95 Cathodic Disbondment 1.5 volts @ 77°F. Results to equal no more than 0.5mm undercutting after 30 days.
      c. Immersion testing rated on using ASTM D-714.
         1) 20% Sulfuric Acid – No effect after two years.
         2) 140°F 25% Sodium Hydroxide – No affect after two years.
         3) 160°F Distilled Water – No effect after two years.
         4) 120°F Tap Water (scribed panel) – 0.0 undercutting after two years with no effect.
      d. An abrasion resistance of no more than 3 mils (0.075mm) loss after one million cycles using European Standard EN 598: Section 7.8 Abrasion resistance.

2.03 POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

A. General
   1. Pipe and fitting size shall be as indicated on the Drawings.

2. PVC materials shall comply with ASTM D1784.
3. PVC pipe is allowable for gravity sewers and pressure pipe.

B. AWWA C900: C900 PVC pipe 4-inch to 60-inch shall conform to AWWA C900 and the following requirements:
1. Outside diameter shall conform to ductile-iron pipe.
2. Pipe DR shall be as shown on the Drawings.
3. Pipe shall have plain end and elastomeric-gasket bell ends.
4. Fittings shall conform to AWWA C110 or C153 and have mechanical joints. Fittings shall be made of gray-iron or ductile-iron. Interior of fittings shall be cement-mortar lined with seal coat in accordance with AWWA C104. Fittings 12” and larger in diameter shall be protected by Protecto 401 Ceramic Epoxy liner or equal.

2.04 POLYVINYL CHLORIDE (PVC) GRAVITY PIPE

A. General
1. All PVC pipe shall be designed in accordance with AWWA M23 PVC Pipe – Design and Installation and the Unibell Handbook of PVC Pipe Design and Construction by the PVC Pipe Association.
2. PVC materials shall comply with ASTM D1784 and D3034.
3. See Section 31 23 33, Trenching for Utilities, for trench bedding and haunching requirements.

B. Sewer Mains:
1. Pipe size and DR shall be as shown on the Drawings.
2. Pipe shall have an integral elastomeric-gasket bell end. Gaskets shall be in conformance with ASTM F477.
3. Nominal pipe length shall be a minimum of 13 feet.

C. Sewer Services:
1. Pipe and fittings shall be Schedule 40 or 80 as specified on the drawings.
2. Schedule 40 fittings shall be manufactured in accordance with ASTM D2466. Schedule 80 fittings shall be manufactured in accordance with ASTM D2467.
3. Joints shall be solvent cement weld. Solvent cement shall be in accordance with ASTM D2564. Joints shall be made in strict accordance with the pipe manufacturer’s recommendations including necessary field cuttings, sanding of pipe ends, joint support during setting period, etc.

2.05 CENTRIFUGALLY CAST FIBERGLASS REINFORCED POLYMER MORTAR (CCFRPM) PIPE

A. CCFRPM Pipe is allowable only for gravity sewers.

B. Pipe and fittings shall conform to the following requirements:
1. Size and stiffness class (SN) shall be as indicated on the Drawings.
2. Pipe shall be supplied in 20-foot nominal lengths.
3. Each length of pipe, fittings, couplings, and specials to be used shall be plainly and permanently marked with the following: pipe class or strength designation, manufacturer’s name or trademark, date of manufacture, and the nominal pipe size.

C. CCFRPM Pipe shall conform to ASTM D3262, for CCFRPM pipe manufactured of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) materials, and to the following requirements:

1. CCFRPM pipe shall be as manufactured by HOBAS Pipe.
2. The pipe shall be manufactured in accordance with ASTM D3262 and shall meet the following cell limits: Type 1, Liner 2, Grade 3, as described by Section 4.2 and Table 1 of ASTM D3262. The stiffness is to be measured in accordance with ASTM D2412. The corrosion liner shall not be considered as contributing to the structural strength of the pipe.
3. The pipe shall be manufactured by the centrifugal casting process resulting in a dense, nonporous, corrosion-resistant, consistent, composite structure to meet the operating conditions as shown on the Drawings.
4. Pipe shall conform to ASTM D2412 for minimum stiffness and external loading characteristics.
5. Couplings, fittings and push-on joints shall be manufactured with flexible, elastomeric seals conforming to the requirements of ASTM D4161 and ASTM F477 and shall meet or exceed the pipe class at the location of its installation.
6. Pipe joint shall be push-on type couplings unless specified otherwise.
7. Pipe shall meet the minimum requirements of ASTM D3681 and ASTM D3262. Manufacturer shall provide complete 10,000-hour test results on pipe produced at the proposed location of manufacture. Results shall reflect that the pipe has a minimum allowable strain of no less than 0.9% at fifty years when tested in accordance with ASTM D3681 and D3262.
8. Normal production pipe for this project shall not incorporate raw materials that are not in compliance with ASTM D3681 and ASTM 3262.
9. Interior of pipe shall be manufactured using a nonstructural resin with a minimum allowable elongation of 50% when measured in accordance with ASTM D638. The liner nominal thickness shall be 40-mils.
10. Exterior pipe surfaces shall be comprised of a layer of sand and resin to provide UV protection to the exterior.

2.06 FILAMENT-WOUND FIBERGLASS REINFORCED POLYMER MORTAR PIPE

A. Filament-Wound Fiberglass Reinforced Polymer Mortar Pipe is allowable only for gravity sewers.

B. Pipe and fittings shall conform to the following requirements:
   1. Size and stiffness class (SN) shall be as indicated on the Drawings.
   2. Pipe shall be supplied in nominal lengths no less than 20-foot long and not greater than 40-foot long.
   3. Each length of pipe, fittings, couplings, specials to be used shall be plainly and permanently marked with the following: pipe class or strength designation, manufacturer’s name or trademark, date of manufacture, and the nominal pipe size.
   4. Wall Thickness: The average wall thickness of the pipe shall not be less than the nominal wall thickness published in the manufacturer’s literature, and the minimum wall thickness at any point shall not be less than 87.5% of the nominal wall thickness.
   5. End Squareness: All points around each end of a pipe unit shall fall within +/-1/4 inch or +/-0.5% of the nominal diameter of the pipe, whichever is greater, to a plane perpendicular to the longitudinal axis of the pipe.
   6. Stiffness: Each pipe shall have sufficient strength to exhibit the minimum pipe stiffness at 5% deflection as required by the Engineer. Stiffness shall be tested in accordance with the test method of ASTM D2412. A minimum of one pipe shall be tested every 100 lengths of each type, grade, and size pipe produced.
   7. The minimum inside diameter of pipe shall meet the requirements of ASTM D3262 for Nominal Inside Diameters (ID) and Tolerances Inside Diameter Control Pipe.

C. Filament-Wound Fiberglass Reinforced Polymer Mortar Pipe shall conform to ASTM D3262, for fiberglass reinforced polymer mortar pipe manufactured of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) materials, and to the following requirements:
   1. The pipe shall be manufactured by Thompson Pipe Group/Flowtite Pipe or Future Pipe Industries.
   2. The pipe shall be manufactured in accordance with ASTM D3262 with a minimum nominal pipe stiffness of (SN) as shown on the Drawings. The pipe shall meet the following cell limits; Type 1, Liner 1 and Grade 1, according to the parameters of ASTM D3262.The stiffness is to be measured in accordance with ASTM D2412. The corrosion liner shall not be considered as contributing to the structural strength of the pipe.
   3. The pipe shall be manufactured by the continuous advancing mandrel (filament wound) process resulting in a dense, nonporous, corrosion-resistant, consistent, composite structure to meet the operating conditions as shown on the Drawings.
   4. Pipe shall conform to ASTM D2412 for minimum stiffness and external loading characteristics.
   5. Couplings, fittings and push-on joints shall be manufactured with flexible, elastomeric seals conforming to the requirements of ASTM D4161 and ASTM F477 and shall meet or exceed the pipe class at the location of its installation.
   6. Pipe joint shall be push-on type double bell couplings with dual gaskets on either side of the coupling unless specified otherwise.
   7. Pipe shall meet the minimum requirements of ASTM D3681 and ASTM D3262. Manufacturer shall provide complete 10,000-hour test results on pipe produced at the proposed locaton of manufacture. Results shall reflect that the pipe has a minimum allowable strain of no less than 0.65% at fifty years when tested in accordance with ASTM D3681 and D3262. The pipe manufacturer may provide a 1,000 hr Reconfirmation Test of Strain Corrosion per ASTM D3681 to satisfy the requirement of testing of pipe at proposed manufacturing location. This does not relieve manufacture from original 10,000-hour test. All testing shall be 3rd party witnessed and reports submitted.
   8. Normal production pipe for this project shall not incorporate raw materials that are not in compliance with ASTM D3681 and ASTM 3262.
   9. Interior of pipe shall be manufactured using a glass reinforced thermoset liner.. The liner nominal thickness shall be 40-mils.
   10. Exterior pipe surfaces shall be comprised of non-structural layer of glass reinforced resin to provide UV protection to the exterior.

D. Resin Systems: The manufacturer shall use only approved polyester or vinyl ester resin systems with a proven history of performance in this particular application.

E. Glass Reinforcements: The reinforcing glass fibers to be used to manufacture the components shall be of the highest quality commercial grade of glass filaments suitably treated with binder and sizing compatible with impregnating resins.

F. Silica Sand: Sand shall be minimum 98% silica with a maximum moisture content of 0.2%

G. Additives: Resin additives, such as curing agents, pigments, dyes, fillers, thixotrophic agents, etc., when used, shall not detrimentally affect the performance of the product.

H. Elastomeric Gaskets: Gaskets shall be supplied by qualified gasket manufacturers and be suitable for the service intended.

2.07 MANHOLES - GENERAL

A. Provide manholes to the depth as indicated on the Drawings. Manhole style, type, and inside diameter shall be as noted on the Drawings.

B. Manholes on lines 12" and larger in diameter, as well as manholes that directly receive a force main discharge, shall be polymer concrete manholes or precast concrete manholes internally coated with a polyurea or epoxy coating.

2.08 PRECAST CONCRETE MANHOLES

A. Provide manholes made of precast concrete sections in conformance with ASTM C478, the Drawings, the City of Raleigh Public Utilities Handbook, NC Department of Transportation, and the requirements that follow:

B. General:
  1. Precast concrete manholes shall be as manufactured by Tindall Concrete Products, Inc., Adams Concrete, Hanson Pipe and Precast, Lindsay Precast, Oldcastle, or approved equal.
  2. T-series manholes as manufactured by Tindall Concrete Products or approved equal shall be an acceptable substitute to round manholes as specified herein. The T-series shall be the same size manhole as shown on the Drawings for round manholes (e.g., 6' ID manhole, etc.) and shall meet all applicable requirements of the specifications. No reduction in size of the riser sections and top slab shall be allowable.

C. Coatings:
  1. When applying coatings to new manholes, coatings will be applied above ground (before manhole components are installed). Areas to be coated shall meet coating manufacturer requirements for surface preparation. Joints shall be coated after manhole installation.

  2. Polyurea:
     a. Coating shall be Duramer 1030 as manufactured by SewerKote or approved equal. Coatings may be applied by brush, spray, or roller. Coating shall be provided in three separate parts; primer, intermediate coat, and top coat.
     b. Primer coat shall be a 20% solids, deeply penetrating, dual-component polyurea primer applied to 0.5 – 1.0 mils dry film thickness (150 $ft^2$/gal).
     c. Intermediate coat shall be a dual component polyurea applied at 50 – 100 mils dry film thickness (50 $ft^2$/gal).
     d. Top coat shall be a 65% solids, two-part polyurea applied at 7.5 – 10 mils dry film thickness (125 $ft^2$/gal).

  3. Epoxy:
     a. The epoxy system shall be a spray applied, two component, 100% solids, solvent-free epoxy developed specifically for use in the wastewater environment. Epoxy liner shall be Raven 405, manufactured by Raven Lining Systems; Dura-Plate 5900 or 6100 manufactured by Sherwin-Williams; Perma-shield $H_2S$ Series 434 and Perma-glaze Series 435, manufactured by Tnemec, or approved equal.
     b. Application procedures for the epoxy lining system shall be in accordance with the manufacturer's recommendations, including materials handling, mixing, environmental controls during application, safety and spray equipment.
     c. The epoxy liner, when cured, shall have the following minimum characteristics measured by the applicable ASTM standards referenced herein:

| | | | |
|---|---|---|---|
| 1) | Hardness, Shore D | ASTM D-2240 | 70 |
| 2) | Tensile Strength | ASTM D-638 | >7,000 psi |
| 3) | Flexural Strength | ASTM D-790 | >10,000 psi |

  4. When cured, the lining shall form a continuous, tight-fitting, hard, impermeable surface which is suitable for sewer system service and chemically resistant to any chemicals or vapors normally found in domestic sewage.

5. The lining shall be compatible with the thermal condition of the existing sewer manhole surfaces. Surface temperatures will range from 20°F to 100°F.

D. Precast Concrete Sections:
   1. Minimum wall thickness shall be 5-inches.
   2. Base: Cast monolithically without construction joints or with an approved PVC waterstop in the cold joint between the base slab and the walls. Minimum thickness of base shall be 6-inches.
   3. The width of the base extensions on Extended Base Manholes shall be no less than the base slab thickness. Extended bases shall comply with the details on Drawings.
   4. Riser: Minimum lay length of 16 inches.
   5. Cone: Eccentric or concentric cones may be used on 8 through 12-inch mains. Concentric cones shall be used on all 15-inch and larger mains.
   6. Transition Slab: Provide a flat transition from 60-inch and larger manholes to 48-inch diameter risers, cones, and flat slab top sections. The maximum height of manhole over the transition top section shall be 12 feet. Transition sections shall not be used in areas subject to vehicle traffic.
   7. Flat Slab Top: Designed for HS-20 traffic loadings as defined in ASTM C890. Items to be cast into Special Flat Slab Tops (i.e. ring, cover, vent base) shall be sized to fit within the manhole ID and the top and bottom surfaces. Provide a float finish for exterior slab surface.
   8. Precast or core holes for pipe connections. Diameter of hole shall not exceed outside diameter of pipe by more than 3-inches.
   9. Lifting Devices: Devices for handling precast components shall be provided by the precast manufacturer and comply with OSHA Standard 1926.704.

E. Joints:
   1. Manufacturer in accordance with tolerance requirements of ASTM C 990 for butyl type joints.
   2. Minimize number of joints. Do not use riser section for manholes up to 6 feet tall and no more than one riser for each additional 4 feet in height.
   3. Flexible Joint Sealants: Flexible Joint Sealants: Preformed butyl rubber based sealant material conforming to Federal Specification SS-S-210A, Type B and ASTM C990.
   4. External Seal: Polyethylene backed flat butyl rubber sheet no less than 1/16-inch thick and 8-inches wide.

F. Inverts:
   1. Brick and mortar or precast concrete invert constructed to the width of the effluent pipe.
   2. Form and finish invert channel to provide a consistent slope from inlet(s) to outlet up to 6-inches.
   3. Channel walls shall be formed to the springline of the outlet pipe diameter.
   4. Finish benches at 60 degrees to manhole walls. Provide a 1/4-inch radius at the edge of bench and trough.

G. Flexible Pipe Connectors: Provide flexible connectors for pipe to manhole that conform to ASTM C923. Location of connectors shall vary from Drawings no more than 1/2-inch vertically and 5 degrees horizontally. Boot sleeves shall have stainless steel expansion bands and pipe clamps that meet or exceed ASTM C923.

H. Steps:
   1. Steps are not allowed inside manholes.
   2. Steps shall be provided on outside of raised manholes when top elevation is greater than three (3) feet above existing ground elevation.

2.09 POLYMER CONCRETE MANHOLE

A. General:
1. Polymer concrete manholes shall be non-porous, corrosion-resistant, homogenous, composite structures.
2. Provide manholes to the depth as indicated on the Drawings. Manhole style, type, and inside diameter shall be as noted on the Drawings.
3. Provide manholes with manufacturing tolerances per ASTM C478.
4. Provide base with riser as a monolithic section, unless shown otherwise.
5. Extended bases: the width of the base extensions on extended base manholes shall be no less than the base slab thickness. Extended bases shall comply with the details on Drawings.
6. Manhole shall support dead and live loads including vehicle loads.
7. Manhole wall thickness shall be designed to resist hydrostatic pressures with a minimum safety factor of 2.0. Wall thickness shall be consistent from invert to grade. Wall thickness shall be a minimum of 4".
8. Cones and adjusting rings shall be made of the same polymer concrete material.
9. Manholes shall include engineered lifting devices that shall not penetrate through the wall.
10. Portland cement concrete shall not be used.
11. Polymer concrete manholes and structures shall be manufactured by U.S. Composite Pipe, Inc. (Thompson Pipe Group), Armorock, or pre-approved equal.

B. Materials:
1. Manhole shall consist of thermosetting resin, sand, and aggregate.
2. Resin content shall be a minimum of 7% by weight. Resin shall be suitable for sewer applications.
3. If resin additives, such as curing agents, pigments, dyes, fillers, and thixotropic agents, are used, they shall not be detrimental to the manhole.
4. Patching or grouting material, if needed, shall be a polyester mortar compound provided by the manhole manufacturer or equal that is approved by the manufacturer.

C. Joints:
1. Provide riser sections with bell and spigot type joints.
2. Manufacturer in accordance with tolerance requirements of ASTM C 990 for butyl type joints.
3. Minimize number of joints. Do not use riser section for manholes up to 6 feet tall and no more than one riser for each additional 4 feet in height.
4. Flexible Joint Sealants: Flexible Joint Sealants: Preformed butyl rubber based sealant material conforming to Federal Specification SS-S-210A, Type B and ASTM C990.
5. External Seal: Polyethylene backed flat butyl rubber sheet no less than 1/16-inch thick and 8-inches wide.

D. Inverts
1. Factory cast invert(s) into base section with polymer concrete.
2. Provide a consistent slope from inlet(s) to outlet.
3. Channel walls shall be formed to the springline of the outlet pipe diameter.
4. Finish benches at 60 degrees to manhole walls. Provide a 1/4-inch radius at the edge of bench and trough.

E. Flexible Pipe Connectors: Provide flexible connectors for pipe to manhole that conform to ASTM C923. Location of connectors shall vary from Drawings no more than 1/2-inch vertically and 5 degrees horizontally. Boot sleeves shall have stainless steel expansion bands and pipe clamps that meet or exceed ASTM C923.

2.10 CASTINGS

A. General
1. Made of gray iron, ASTM A-48 - class 30.
2. Castings shall be free from imperfections not true to pattern. Casting tolerances shall be plus or minus 1/16-inch per foot of dimension. Top shall set neatly in frame, with edges machined for even bearing and proper fit to prevent rattling and flush with the edge of frame.
3. Castings shall be as manufactured by Neenah Foundry Co., U.S. Foundry & Manufacturing Corp., or approved equal.

B. Manhole Frame and Cover:
1. Minimum clear opening shall be 22 inches.
2. Minimum weight for frame and cover shall be 300 pounds and suitable for Heavy Duty Highway Traffic Loads of H-20.
3. Frame shall have four 3/8-inch anchor bolt holes equally spaced.
4. Cast "SANITARY SEWER" and "DANGER PERMIT REQUIRED – CONFINED SPACE DO NOT ENTER" on the cover. Casting shall bear the name of the manufacturer and the part number.
5. Provide camlocks on all manholes located in sanitary sewer easement.
6. Provide cover with one 1-inch perforated hole unless noted as watertight on the Drawings.
7. Provide the following where indicated on the Drawings:
   a. Ring and cover shall be watertight.
   b. Bolt down cover. Bolt down covers shall be provided with four (4) 3/8-inch stainless steel hex head bolts at 90 degrees.

2.11 COMPOSITE FRAME AND COVER

A. Composite frame and cover shall not be used in roadways.

B. Minimum clear opening shall be 22 inches.

C. Cover shall be heavy duty with minimum H-20 load rating.

D. "SANITARY SEWER" and "DANGER PERMIT REQUIRED – CONFINED SPACE DO NOT ENTER" shall be included on the cover.

E. Provide cover with one 1-inch perforated hole unless noted as watertight on the Drawings.

F. Provide stainless steel camlocks on all composite covers. Cam locks shall be operable without any special tools.

G. Where required, provide gasket for watertight cover.

H. Provide cover with manhole pick access.

I. Frame and cover shall be provided by the same manufacturer.

J. Frame and cover shall be manufactured by EJ, Trumbull Manufacturing, Composite Access Products, or equal.

2.12 SEWER SERVICE

A. Provide PVC wye sewer saddles for services on PVC mains. Saddles shall be solvent welded and fastened with double stainless-steel bands.

B. Provide a cast or ductile iron wye sewer saddle for services on ductile iron main. Saddles shall be "Geneco E40" sewer saddles or approved equal consisting of a virgin SBR gasket compounded for sewer service, a ductile iron saddle casting, a 304 stainless-steel adjustable strap for fastening the gasket and the saddle casting to the sewer main, and a 304 stainless steel adjustable circle clamp for securing the service line into the SBR gasket.

C. Sewer service shall include all required fittings, including new PVC cleanout.

## 2.13 VALVES

A. General: Valves shall meet the following requirements:
1. Size shall be as required for the pipe size and material as indicated on the Drawings and specified.
2. Open by counterclockwise rotation.
3. Standard system working pressure is pressure 175 psi.
4. Equip valves with a suitable means of operation.
5. For buried valves over 5 feet deep, provide extension stems of cold rolled steel to bring the operating nut to within 2 feet of the ground surface.
6. Provide valve accessories as required for proper valve operation for valve locations as indicated on the Drawings and as recommended by valve manufacturer.
7. Valve accessories shall be compatible to proper valve operation.
8. Similar valve types shall be of one manufacturer.

B. Gate Valves, Resilient-Seated: Gate valves 3-inch to 36-inch shall conform to AWWA C509 for and to the following requirements:
1. O-ring stem seal on non-rising (NRS) stem valves.
2. Ends shall be mechanical joint for underground locations and flanged joint for above ground locations.
3. Valves shall be non-rising stem (NRS) with wrench nut for underground locations and Outside Screw and Yoke (OS&Y) with handwheel for above ground locations unless noted otherwise on the Drawings.
4. Be of one manufacturer.
5. Valves 16-inch and larger shall be equipped with cast iron gearing to facilitated opening. Gear cases shall be extended or totally enclosed type. Geared valves shall be equipped with indicators to show the position of the gate in relation to the water.
6. Valves 20-inch and larger shall be equipped with a bypass.

C. Plug Valves: Plug valves shall conform to the following requirements:
1. Plug valves shall be of the non-lubricated, eccentric type designed for a working pressure of 175 psi for valves 12 inch and smaller, 150 psi for vales 14 inch and larger.
2. Valves shall provide tight shut-off at rated pressure.
3. The plug valve body shall be cast iron ASTM A126 Class B with a welded-in overlay of not less than 90% nickel alloy content on all the surfaces contacting the face of the plug.
4. The valve plug shall be constructed of cast iron conforming to ASTM A126 Class B, with Buna N resilient seating surface to mate with the body seat.
5. Valve flanges shall be in accordance with ANSI B16.1 Class 125.
6. Shaft bearings shall be sleeve-type, sintered, oil impregnated, and permanently lubricated stainless steel.
7. Plug valve shaft seals shall be of the multiple V-ring type and shall be adjustable. Sealing system shall conform to AWWA C504 standards. All packing shall be replaceable without removing the bonnet or actuator and while valve is in service.
8. Valves 6" and larger shall be provided with gear actuators.

9. Provide levers or hand wheels to operate the valve as recommended by the manufacturer.

D. Swing Check Valves: Swing check valves from 2 to 24-inch shall conform to AWWA C508 and to the following requirements:
1. Provide lever and weight for swing check control.
2. Resilient material to Metal seat construction.
3. Ends shall be flanged.

2.14 AIR RELIEF VALVES

A. Provide air valves in conformance with AWWA C512 and the following:
1. Valve type shall be a combination valve.
   a. Inlet size: 2 inch
   b. Large orifice minimum: 1 inch
   c. Small orifice minimum: 1/8 inch
2. Valve shall be designed for the following automatic operation:
   a. Release of large quantities of air during the filling of the main.
   b. Permit air to enter the main when it is being emptied.
   c. Release accumulated air while the main is in operation and under pressure.
3. Valve shall be designed for a system pressure 150 psi. Valve shall also operate at a minimum system pressure of 20 psi.
4. Provide threaded inlet.
5. Provide stainless steel ball float and internal trim.
6. Provide isolating bronze ball valve for connection to main line.
7. For sewage force mains provide tall body to minimize possibility of sewage plugging orifice or linkage.
8. Sewage force main valve shall include backwash accessories. They shall include bronze flushing ball valves and 5 feet of rubber hose with quick-connect coupling on each end.

2.15 VALVE BOX

A. Valve Box, Below Ground: Boxes shall be high strength cast iron of the screw or telescopic type. Box shall consist of a base section, center extension as required, and a top section with cover marked “SEWER.”

2.16 THRUST BLOCKING

A. Provide concrete thrust blocking for pressure lines in accordance with the detail on the Drawings.

B. Thrust blocking is not required where restrained joint fittings and equivalent length of restrained joint pipe are used unless shown otherwise on the Drawings.

2.17 GEOTEXTILE WRAP FOR FRP SANITARY SEWER

A. Provide geotextile fabric wrap for use as FABRIC FOR SOIL STABILIZATION. The fabric shall:
1. Consist of strong, rot-proof synthetic fibers formed into a woven fabric.
2. Be free from any treatment or coating which might significantly alter its physical properties before or after installation.
3. Contain stabilizers and/or inhibitors to make the filaments resistant to deterioration resulting from ultraviolet or heat exposure.
4. Be a pervious sheet of synthetic fibers oriented into a stable network so that the fibers retain their relative position with respect to each other.
5. Be free from defects or flaws which significantly affect its physical and/or filtering properties.

6. Meet the physical properties and classification as a Type 4, Fabric for Soil Stabilization in accordance with NCDOT Table 1056-1."

PART 3 EXECUTION

3.01 GENERAL

A. Pipe installation shall meet the following general guidelines:
   1. Lay pipe in the presence of the Owner's designated resident project representative, unless specifically approved otherwise.
   2. Handle pipe and accessories in accordance with manufacturer's recommendations. Take particular care not to damage pipe coatings.
   3. Carefully inspect pipe immediately prior to laying. Do not use defective pipe. Replace pipe damaged during construction.
   4. Lay pipe to grade and alignment indicated on the Drawings.
   5. Provide proper equipment for lowering pipe into trench.
   6. Provide tight closure pipe ends when work is not in progress.
   7. Keep pipe interior free of foreign materials.
   8. Do not lay pipe in water or when the trench or weather conditions are unsuitable for the work.
   9. Clean bell and spigots before joining. Make joints and lubricate gasket in accordance with pipe manufacturer recommendation.
   10. Block fittings with concrete or restrained as indicated on the Drawings or as required to prevent movement.

B. Gravity Pipe: Gravity pipe installation shall meet the following general guidelines:
   1. Lay pipe upgrade from the lower end and at the grades and alignment indicated on the Drawings.

3.02 RELATION OF WATER MAINS TO SEWERS

A. Lateral Separation: Lay water mains at least 10 feet laterally from existing and proposed sewers. Where existing conditions prevent a 10-foot lateral separation, the following shall be followed with approval of the Engineer:
   1. Lay water main in a separate trench, with the elevation of the bottom of the water main at least 18 inches above the top of the sewer.
   2. Lay water main in the same trench as the sewer with the water main located at one side on a bench of undisturbed earth, and with the elevation of the bottom of the water main at least 18 inches above the top of the sewer.

B. Crossing Separation: Lay bottom of water main at least 18 inches above the top of the sewer. Where existing conditions prevent an 18-inch vertical separation, construct both the water main and sewer of ferrous materials and with joints that are equivalent to water main standards for a distance of 10 feet on each side of the point of crossing.

C. Crossing a Water Main Under a Sewer: When it is necessary for a water main to cross under a sewer, construct both the water main and the sewer of ferrous materials and with joints equivalent to water main standards for a distance of 10 feet on each side of the point of crossing. A section of water main pipe shall be centered at the point of crossing.

3.03 GRAVITY SEWER PIPE

A. Lay sewer pipe to true lines and grades by using laser beam equipment or other acceptable means.

B. Minimum Separation Distances:
   1. In general, 100-foot horizontal separation from wells or other water supplies. If sewer pipe is installed within 50 foot of a public well or water supply or 25 foot of a private well or water supply, ferrous pipe must be used. Manholes shall not be located within 50-foot of a public well or water supply or 25 foot from a private well or water supply.
   2. 24-inch vertical separation from storm sewers or ferrous pipe shall be used.
   3. For separation from water mains see paragraph 3.02 above.

3.04 DUCTILE IRON PIPE

A. Install pipe in conformance with AWWA C600 and the following:
   1. For laying pipe in a vertical or horizontal curve, each full-length pipe may be deflected by the following offset distance unless the pipe manufacturer's recommended distances are less:
      a. Push-on joint
         1) 3 to 12-inch pipe: 14-inch offset
         2) 14 to 36-inch pipe: 8-inch offset
      b. Mechanical joint
         1) 3 to 6-inch pipe: 20-inch offset
         2) 8 to 12-inch pipe: 15-inch offset
         3) 14 to 20-inch pipe: 8-inch offset
         4) 24 to 36-inch pipe: 6-inch offset
   2. For laying restrained joint pipe in a vertical or horizontal curve, except for horizontal directional drills (HDD), each full-length pipe may be deflected by the following offset distance:
      a. 6 to 12-inch pipe: 11-inch offset
      b. 16 to 20-inch pipe: 7-inch offset
      c. 24 to 30-inch pipe: 5-inch offset
      d. 36-inch pipe: 4-inch offset
      e. 42 to 48-inch pipe: 1 ¼ -inch offset
   3. For laying restrained joint pipe in a vertical or horizontal curve, except for horizontal directional drills (HDD), each full-length pipe may be deflected by the following offset distance:
      a. 6 to 12-inch pipe: 11-inch offset
      b. 16 to 20-inch pipe: 7-inch offset
      c. 24 to 30-inch pipe: 5-inch offset
      d. 36-inch pipe: 4-inch offset
      e. 42 to 48-inch pipe: 1 ¼ -inch offset
   4. The Contractor shall verify the offset distances specified are acceptable with the pipe manufacturer prior to installation.
   5. Carrier pipe of any joint type may not be deflected.

3.05 DUCTILE IRON PIPE LINER

A. Application
   1. The entire surface shall be inspected prior to receiving protective compound to ensure that no oil, grease, etc. exists on the surface. If any surface contains any of these items shall be solvent cleaned to remove said substances.
   2. Once free of any oil, grease, etc., all surfaces shall be abrasive blasted using sand or grit abrasive media. No rust shall be present on surface at the time of application.
   3. After surface preparation, the pipe interior shall receive 40 mils nominal dry film thickness of Protecto 401 or approve equal. Follow manufacturer's thickness requirements.

4. No lining shall take place when the substrate or ambient temperature is below 40°F.
5. The surface must be dry and dust free during application.
6. Bell Sockets and Spigot Ends shall be coated with 6 mils nominal, 10 mils maximum with Protecto Joint Compound 6 inches back from the end of the spigot end.
7. The joint compound shall be applied by brush to ensure full coverage.
8. No excessive buildup shall be present in the gasket seat or on the spigot ends.
9. Coating of the gasket seat and spigot ends shall be done after the application of the lining to the interior of the pipe.
10. The number of coats shall be as recommended by the lining manufacturer.
11. No material shall be used for lining which is not indefinitely recoatable with itself without roughening of the surface.
12. Provide touch up, as necessary, using Protecto Joint Compound per manufacturer's recommendations.

B. Inspection and Certification
1. A magnetic film thickness gauge shall be used to confirm the thickness on all ductile iron pipe and fittings. Thickness testing shall be done in accordance with SSPC-PA-2 Film Thickness Rating.
2. The interior lining shall be tested using a non-destructive 2,500 volt test to check for pinholes. Repair defects prior to shipment.
3. Each pipe joint and fitting shall be marked with the date of application of the lining system along with its numerical sequence of application on that date and records maintained by the applicator of his work. These records shall be made available to the Engineer upon request.
4. The pipe/fitting manufacturer shall provide a certificate attesting that the applicator meets the requirements of this specification, and that the material used was as specified and applied as specified.

3.06 PVC PRESSURE PIPE

A. Install PVC C900/ pipe in conformance with AWWA C605.

B. Bell and Spigot Joints: Clean bell and spigot ends prior to jointing. Ends of field cut pipe shall be beveled with file. Gasket shall be clean and lightly lubricated. Joint shall be made as recommended by the manufacturer.

3.07 FIBERGLASS REINFORCED PIPE – CENTRIFUGALLY CAST AND FILAMENT WOUND

A. Install pipe in accordance with manufacturer's recommendations and the following requirements:
1. The bedding and burial of pipe and fittings shall be in accordance with the Drawings and Specifications and the Manufacturer's requirements.
2. Do not exceed forces recommended by the manufacturer when joining pipe.
3. Gasket shall be wiped clean prior to joining. Damaged, defective, or bulging gaskets shall be replaced with a new coupling.
4. Wipe the plain end of pipe clean prior to insertion in the coupling. The coupling components shall also be wiped clean prior to connection.
5. Apply joint lubricant, as approved by pipe manufacturer, to pipe end and elastomeric gaskets.
6. For handling pipe, use textile slings or other suitable materials or a forklift. Use of cables or chains is not permitted. Damaged pipe will be rejected.
7. Pipe shall be free of nicks, scratches and gouges at the time of installation. Visible gouges shall be cause for rejection of pipe.

8. Join pipe in straight alignment then deflect slightly if required. Do not allow the deflection angle to exceed the deflection permitted by the manufacturer.
9. No blocking under the pipe will be permitted.
10. Storage of pipe on the job site shall be done in accordance with the pipe manufacturer's recommendation and with approval of the Engineer.
11. Under no circumstances shall pipe or fittings be dropped either into the trench or during unloading. The interior of the pipe shall be kept clean of oil, dirt, and foreign matter; and the machined ends and couplings shall be wiped clean immediately prior to jointing.
12. Use a pipe cutter where necessary to cut and machine all pipe in the field. A "full insertion mark" shall be provided on each field-cut pipe end. Field-cut pipe shall be beveled with a beveling tool in accordance with the manufacturer's recommendations. Bevels shall be in accordance with the manufacturer's requirements.
13. If not integral to the bell or coupling, rubber gaskets shall be marked with manufacturer's identification sizes and proper insertion direction.
14. Before use, all pipe and specials shall be thoroughly examined for defects; and no piece shall be installed which is known to be defective. If any defective piece should be discovered after having been installed, it shall be removed and replaced with a sound on in a satisfactory manner at no additional cost to the Owner.
15. For open-trench construction, the laying of the pipe in finished trenches shall begin at the lowest point with the coupling/bell ends pointing opposite to the direction of flow. The interior of the pipe and the jointing seal shall be free from sand, dirt, and trash before installing in the line. Extreme care must be taken to keep the couplings of the pipe free from dirt and rocks so joints may be properly assembled without overstressing the coupling. The jointing of the pipe shall be done in strict accordance with the pipe manufacturer's instructions and shall be done entirely in the trench.
16. Fiberglass reinforced pipe shall be aligned and joined in accordance with each manufacturer's recommendations. Joining of pipe shall not exceed the maximum allowable misalignment for each manufacturer's installation requirements. Contractor shall inspect the joint of each section of pipe throughout the circumference of the joint prior to backfilling to determine offset or misalignment of the joint and measure. Any offset greater than the maximum allowable for the specified pipe material shall be field adjusted, re-inspected, and re-measured prior to backfilling of the pipe section.
17. Geotextile shall be utilized for filtration and stabilization of stone bedding, haunching, and initial backfill when loose, non-cohesive soils are encountered. Contractor is responsible for identifying potential locations for geotextile bedding wrap and confirming with Owner's geotechnical representative. Geotextile wrap shall be installed in accordance with AASHTO M288-06, Appendix X1 and manufacturer's installation recommendations. Prior to covering, the geotextile material shall be inspected for damage during installation. Damaged geotextiles shall be replaced or repaired immediately at no additional cost to the Owner. Sheets of fabric may be sewn or bonded together with a fungus resistant material in accordance with AASHTO M288-06, Appendix X1.1.4. No deviation from any physical requirements will be permitted due to the presence of the seam. When anchor pins are necessary, fabricate them of steel, 3/16" in diameter, at least 18" long, pointed at one end, and have a head that will retain a steel washer having an outside diameter of no less than 1.5". When wire staples are necessary, provide staples made of No. 11 gage new steel wire formed into a "U" shape. The size when formed must not be less than 6" in length with a throat of not less than 1" in width. Fabric will be rejected if more than 72 hours has elapsed between the time the protective wrapping has been removed and the fabric is covered up during installation. Replacement fabric will be obtained by the Contractor at no additional cost to the Owner. Construction vehicles shall not be allowed directly on geotextile. If

placement of backfill material causes damage to the geotextile, the damaged area shall be repaired or replaced at no additional cost to the Owner.

18. When CCFRPM pipe is stored in an area where it is exposed to sunlight or other sources of UV radiation, the ends of each pipe shall be covered to protect the inner liner from exposure in accordance with the manufacturer's recommendations."

3.08 REINFORCED CONCRETE HDPE LINED SEWER PIPE

A. Care shall be taken in loading, transporting, and unloading to prevent damage to the pipe. All pipe shall be examined and approved by the Engineer or his appointed representative before laying and no piece shall be installed which is found to be defective.

B. Preparation of bedding and backfill shall be as specified on the Drawings and per the requirements of the American Concrete Pipe Association's Design Data 9. Pipe shall be laid with uniform bearing under the full barrel of the pipe.

C. Pipe shall be protected from lateral displacement by pipe embedment material installed as provided in the Drawings. Under no circumstances shall concrete pipe be laid in water and no pipe shall be laid in unsuitable weather or trench conditions. Pipe shall be laid with bell ends facing the direction of laying except when making closures.

D. Rubber gaskets shall be installed in strict conformance with the pipe manufacturer's recommendations.

E. Pipe shall be laid to line and grade as shown on the plans. Curves may be formed using fittings, specials, or unsymmetrical joint closure of straight pipe as required.

F. As the pipe line is being laid, and prior to welding of the HDPE liner, each joint shall be tested with a Go/No-Go joint air test to verify joint integrity. The test shall be conducted on the mated joint after two subsequent joints have been laid to confirm that the joint and gasket are assembled properly, i.e. no pinched or rolled gaskets or cracked bells. The test shall consist of using a Cherne Joint Tester (or approved equal) employing a modified test procedure. The modified test shall consist of pressurizing the sealing bladders to 80 psi and then pressurizing the joint to 5 psi. The pressure cannot drop more than 1 psi in 5 seconds for the joint to be considered acceptable. Any problems with the joint (bell, spigot, or gasket) will be identified by the inability to pressurize the joint. If the joint fails this test, the joint shall be removed and replaced using new gaskets then re-tested. All joint tests shall be witnessed and approved by the Engineer or the designated representative.

3.09 VALVES AND FITTINGS

A. Install buried valves on top of an 18-inch square, 3-inch thick, solid concrete pad (minimum dimensions). The concrete pad may be provided by a pre-cast manufacturer or cast-in-place in the field above grade. Concrete used for the pads shall be a minimum 3,000 psi mix. The pads may not be cast-in-place in the pipe trench. Connection to pipe shall be such that there shall be no stress at the joint caused by misalignment or inadequate support of pipe or valve.

B. Install fittings as recommended by the manufacturer. Fittings shall be blocked or otherwise restrained from movement.

C. Valve Boxes: Set valve boxes flush with finished grade. Box shall be supported so that no stress shall be transmitted to the valve. Operating nut shall be centered in box.

D. Install valves, gates, and accessories indicated on the Drawings and in complete accordance with the manufacturer's recommendations.

E. Valve boxes shall be set straight with the operating nut centered and supported on (2) 4" concrete blocks, to prevent load transfer onto valve body or pipe line. Set top of box at finished grade. Provide a 24-inch x 24-inch wide by 6-inch thick concrete pad at top of valve boxes outside paved areas.

3.10 AIR RELIEF VALVES

A. Main shall be drilled for a two-inch connection.

B. Valve shall be installed on the main line with a service saddle.

C. Install air valve in a flat top manhole.

3.11 MANHOLES

A. Set base plumb and level. If using precast inverts, then align manhole invert with pipe invert.

B. Secure pipe connectors to pipe in accordance with manufacturer's recommendation.

C. Clean bells and spigots of foreign material that may prevent sealing. Unroll the butyl sealant rope directly against base of spigot. Do not stretch. Follow manufacturer's instructions when using O-ring seals.

D. Plug lift holes using a non-shrink grout. Cover with a butyl sealant sheet on the outside and seal on the inside with an application of an epoxy gel 1/8-inch thick extending 2 inches beyond the opening.

E. Set manhole frames to grade with grade rings in paved areas. Grade rings are not allowable for manholes located in easements. Seal joints between cone, adjusting rings, and manhole frame with butyl sealant rope and sheet. Concrete collar as shown in detail on the drawings shall be installed for manholes located in pavement.

F. Apply external seal to the outside of joint.

G. Finish the interior by filling fractures greater than 1/2-inch in length, width or depth with a sand cement mortar.

H. Clean the interior of the manhole of foreign matter.

3.12 SEWER CLEANOUTS

A. Sewer cleanouts connected to ductile iron pipe shall also be ductile iron sewer pipe conforming to these specifications.

B. Sewer cleanouts connected to PVC pipe shall also be PVC sewer pipe schedule 40 conforming to ASTM-D-3034 latest revision. Use elastomeric gaskets for pipe joints.

C. PVC wye sewer saddles shall be used on new PVC pipe. Saddles shall be used on existing PVC, solvent welded to the main and fastened with double stainless steel bands.

D. Cleanouts shall be a minimum of 4-inch diameter unless noted otherwise on the Drawings. Provide sewer cleanouts with screw-in watertight cap. Installation shall be in accordance with the details as shown on the Drawings.

3.13 SERVICE CONNECTIONS

A. Make service connections in accordance with the standard detail(s) on the Drawings.

B. Service connections to the main lines shall be perpendicular to the main line to the edge of the right-of-way or easement line.

C. Four-inch lines shall have a minimum slope of 1.0 % and have cleanouts every 75 feet at a minimum in addition to a cleanout at the right-of-way line or at the edge of the easement.

D. Six-inch lines shall have a minimum slope of 0.60 % and have cleanouts every 100 feet at a minimum in addition to a cleanout at the right-of-way line or at the edge of the easement.

E. 6-inch service lines shall tie directly into a manhole.

F. Wye sewer saddles shall be made only when the sewer main is 8-, 10-, or 12-inch diameter concrete, ductile iron, or PVC sewer pipe. This type connection cannot be used on truss sewer pipe. The opening in the sewer main for the saddle shall be cut with a hydraulically driven or pneumatically driven circular tapping saw of the same nominal diameter as the sewer service line.

3.14 PAINTING

A. Equipment shall receive the manufacturer's standard coating for the intended application. Coatings shall be suitable for the intended application.

B. Repaint damaged paint services.

C. Above ground piping and piping within vaults shall be painted in accordance with the specification section for each item.

3.15 TESTING

A. General
1. Clean and flush pipe system of foreign matter prior to testing.
2. Notify Owner and Engineer a minimum of 48 hours prior to testing.
3. Perform tests in the presence of Engineer.
4. Length of line to be tested at one time shall be subject to approval of Engineer.
5. Pipe sections shall not be accepted and placed into service until specified test have been performed and approved.
6. Repair defects in the pipe system. Make repairs to the same standard as specified for the pipe system.
7. Retest repaired sections until acceptance.
8. Repair visible leaks regardless of the test results.

B. Pressure Mains
1. The Engineer shall approve the source, quality, and method of disposal of water to be used in test procedures.
2. Obtain Owner’s permission 48 hours prior to filling or flushing of pipe system with water from Owner’s water system. Owner shall operate valves connected to the existing water system. Keep pipe interior clean during construction to minimize the amount of water required for flushing. Where large quantities of water may be required for flushing, Owner reserves the right to require that flushing be done at periods of low demand.
3. Pressure test in accordance with AWWA C600 for ductile iron pipe and AWWA C605 and M23 for PVC pipe and the following.
4. Make pressure tests between valves. Furnish suitable test plugs where line ends in “free flow.”
5. Provide air vents at the high points in the line section to be tested for releasing of air during filling. Service corporation stops may be used for air vent when located at a high point. Include cost of air vents in price of testing. Leave corporation stops in place after testing and note locations on As-Built Drawings.
6. Allow concrete blocking to reach design strength prior to pressure testing.
7. Force main shall be completely filled with water, all air expelled from the pipe, and the discharge end of the pipeline shall be plugged and adequately blocked before hydrostatic test begins.

8. Upon completing a section of pipe between valves, perform hydrostatic pressure test as follows:
   a. 1.5 times working pressure or 150 psi (whichever is greater) for 2 hours
   b. Test pressure shall not be less than 1.25 times working pressure at highest point along test section.
   c. Test pressure shall not vary by more than +/- 5 psi for the duration of the test.
   d. Test pressure shall not exceed the pressure rating for any system component within the test section.
9. No length of line shall be accepted if the leakage is greater than that determined by the following formula based on the appropriate test pressure:

   L = Allowable leakage per 1,000 feet of pipe in gallons per hour.
   D = Nominal diameter of the pipe in inches.
   100 psi: L = D x 0.07
   150 psi: L = D x 0.08
   200 psi: L = D x 0.09
   250 psi: L = D x 0.10

C. Gravity Sewer Mains
1. Test gravity sewer between manholes using low-pressure air. Each pipe joint/coupling shall be individually tested with a internal joint tester following installation and prior to the next joint/coupling of pipe being installed. The joint/coupling of pipe being tested shall be retested after the next upstream joint/coupling of pipe is tested, to insure that the upstream pipe connection has not caused the initial pipe joint/coupling to lose its seal.
2. Light Testing: Engineer will check for displacement of pipe as follows:
   a. A light will be flashed between the ends of the pipe section being tested.
   b. If the illuminated interior shows misalignment, or other defects as designated by Engineer, defects shall be repaired.
3. General
   a. Infiltration shall not exceed 100 gallons per inch of diameter, per mile of pipe, per 24 hours. Engineer may require flow measurement for verification of infiltration.
   b. Verify that maximum infiltration rate shall not be surpassed by performing an air testing as follows.
4. Low Pressure Air Test:
   a. Air testing of sewer mains shall conform to UNI-B-6 and the following requirements:
   b. Perform initial air test when each section of main is complete including services to right of way. Test as construction proceeds.
   c. Wet interior surfaces of porous pipe material prior to testing.
   d. Safety
      1) Provide a superintendent who has experience in low pressure air testing of gravity sewer mains.
      2) Follow safety recommendations of air testing equipment manufacturer.
      3) Properly brace sewer plugs during testing. Test plugs prior to use in air testing.
      4) No one shall be allowed in manhole or trench when pipe is under pressure.
      5) Pressurizing equipment shall include a regulator and a pressure relief valve, which are set no higher than 9 psig. Monitor gauges continuously to assure that the pressure does not exceed 9 psig.
   e. Equipment
      1) Sewer plugs shall be specifically designed for low pressure air testing.
      2) Use two separate air hoses.
         i) One to connect the control panel to the sealed line for introducing the air.

ii) One from the sealed line to the control panel to provide constant monitoring of the air pressure in the line.

iii) If Pneumatic plugs are used a separate line shall be used to inflate the plugs.

3) As a minimum the above ground air testing equipment shall include a shutoff valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0 to at least 10 psig.

4) Continuous monitoring pressure gauge shall be at least 4 inches in diameter with minimum divisions of 0.10 psi and an accuracy of +/- 0.04 psi.

5) Monitoring gauges shall be subject to calibration as deemed necessary.

6) Air used for testing shall pass through a single above ground control panel.

7) Internal joint testers shall be manufactured by Lansas Products, Plug-It Products, or Cherne Industries, Inc.

f. Testing

1) Groundwater Determination: Immediately prior to each air test, determine groundwater level by a method acceptable to the Engineer. Adjust pressure used in air test in accordance with groundwater level.

2) Apply air slowly to the test section until the pressure reached is 4.0 psi plus an adjustment of 0.433 psi for each foot of ground water above the crown of the pipe. Internal air pressure, including adjustment for ground water, should never exceed 9.0 psi for ductile iron and concrete pipe and 5.0 psi for Fiberglass pipes. The Contractor may have to dewater trench to maintain ground water at or below crown of fiberglass pipe when testing. Cost for this shall be included in unit price for pipe installation.

3) When the above required pressure is reached, throttle air supply to maintain internal pressure for at least two minutes to permit stabilization.

4) When pressure has stabilized at required pressure, shut off air supply.

5) While observing the continuous monitoring pressure gauge, decrease pressure approximately 0.5 psi from required pressure.

6) At this reading timing shall commence with a stop watch and allowed to run until pressure has dropped 1.0 psi or allowable time has lapsed. Line shall be "Acceptable" if the pressure drop does not exceed 1 psig in the time prescribed for the test below in Table 1, Low Pressure Air Testing for Gravity Sewer Mains.

7) Air pressure applied through the internal joint testers shall be in accordance with item 2) above.

TABLE I

LOW PRESSURE AIR TESTING
FOR
GRAVITY SEWER MAINS

MINIMUM TIME REQUIRED FOR A MAXIMUM 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED

| 1 Pipe Dia. (in.) | 2 Minimum Time (min:sec) | 3 Length for Minimum Time (ft) | 4 Time for Longer Length (sec) | 5 Specification Time for Length (L) Shown (min:sec) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100 ft | 150 ft | 200 ft | 250 ft | 300 ft | 350 ft | 400 ft | 450 ft |
| 4 | 3:46 | 597 | .380 L | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 |
| 6 | 5:40 | 398 | .854 L | 5:40 | 5:40 | 5:40 | 5:40 | 5:40 | 5:40 | 5:42 | 6:24 |
| 8 | 7:34 | 298 | 1.520 L | 7:34 | 7:34 | 7:34 | 7:36 | 7:36 | 8:52 | 10:08 | 11:24 |
| 10 | 9:26 | 239 | 2.374 L | 9:26 | 9:26 | 9:26 | 9:53 | 11:52 | 13:51 | 15:49 | 17:48 |
| 12 | 11:20 | 199 | 3.418 L | 11:20 | 11:20 | 11:24 | 14:15 | 17:05 | 19:56 | 22:47 | 25:38 |
| 15 | 14:10 | 159 | 5.324 L | 14:10 | 14:10 | 17:48 | 22:15 | 26:42 | 31:09 | 35:36 | 40:04 |
| 18 | 17:00 | 133 | 7.692 L | 17:00 | 19:13 | 25:38 | 32:03 | 38:27 | 44:52 | 51:16 | 57:41 |
| 21 | 19:50 | 114 | 10.470 L | 19:50 | 26:10 | 34:54 | 43:37 | 52:21 | 61:00 | 69:48 | 78:31 |
| 24 | 22:40 | 99 | 13.674 L | 22:47 | 34:11 | 45:34 | 56:58 | 68:22 | 79:46 | 91:10 | 102:33 |
| 27 | 25:30 | 88 | 17.306 L | 28:51 | 43:16 | 57:41 | 72:07 | 86:32 | 100:57 | 115:22 | 129:48 |
| 30 | 28:20 | 80 | 21.366 L | 35:37 | 53:25 | 71:13 | 89:02 | 106:50 | 124:38 | 142:26 | 160:15 |
| 33 | 31:10 | 72 | 25.852 L | 43:05 | 64:38 | 86:10 | 107:43 | 129:16 | 150:43 | 172:21 | 193:53 |
| 36 | 34:00 | 66 | 30.768 L | 51:17 | 76:55 | 102:34 | 128:12 | 153:50 | 179:29 | 205:07 | 230:46 |

This Table is from UNI-B-6-90. The table is based on a Q (allowable air loss rate in test section) = 0.0015 cubic feet / minute / square feet. To shorten required test time a maximum pressure drop of 0.5 psig may be used and time requirements reduced by half.

5. Deflection Test for SDR 35 and Ribbed (ASTM F 949) PVC pipe.
   a. Measure for deflection of pipe no sooner than thirty days after installation and backfill.
   b. Deflection shall not exceed 5 percent of pipe diameter. Maximum allowable long-term deflection shall be 5 percent.
   c. Measure deflection with an approved "GO-NO-GO GAUGE" method or by an approved recording deflectometer. Verify gauge on site prior to testing.
6. Deflection Test for Fiberglass Pipe.
   a. Measure for deflection of pipe within 48 hours (initial test) after installation and backfill and again (final test) within thirty days.
   b. Deflection shall not exceed 3 percent of pipe diameter for the initial test and 4 percent of pipe diameter for the final test. Maximum allowable long-term deflection shall be 5 percent.
   c. Measure deflection with an approved "GO-NO-GO GAUGE" method or by an approved recording deflectometer. Verify gauge on site prior to testing.

D. Vacuum test each manhole in accordance with ASTM C1244 and the following:
   1. No personnel shall be allowed in manhole during testing.
   2. Test manhole after assembly and prior to backfilling.
   3. Plug pipes with suitably sized and rated pneumatic or mechanical pipeline plugs. Brace plugs to prevent displacement.
   4. Position vacuum test head assembly to seal against interior surface of the top of cone section in accordance with manufacturer's recommendation.
   5. Draw vacuum of 10 inches of mercury on manhole. Shut off the vacuum pump and close valve on vacuum line.
   6. Measure time for vacuum to drop to 9 inches of mercury. Manhole shall pass if time meets or exceeds the following:

| Manhole I.D. (inches) | 48 | 60 | 72 | 84 | 96 | 120 | T-series |
|---|---|---|---|---|---|---|---|
| Seconds | 60 | 75 | 90 | 105 | 120 | 150 | 105 |

   7. If manhole fails test, remove head assembly, coat interior with a soap and water solution, and repeat vacuum test for approximately 30 seconds. Leaking areas will have soapy bubbles. Make necessary repairs to the satisfaction of Engineer and repeat test until manhole passes.

## 3.16 CLEANING AND TV INSPECTION

A. Upon completion of other testing, clean all newly installed sewer mains. This shall include all sewer main and lateral connections. This cleaning shall meet the following requirements:
   1. The Owner's designated resident project representative shall be present throughout the cleaning operations.
   2. The sewer mains shall be cleaned with a high-velocity water jet. No debris of any kind shall be released into the sewer system.

B. Upon completion of cleaning operations, within 2 hours, Owner shall televise all newly installed sewer mains.
   1. Contractor shall coordinate cleaning and televising operations with Owner to ensure time schedules can be achieved.
   2. If televising is not properly coordinated, Owner may request Contractor to clean sewer mains again at no additional cost to the Owner.

END OF SECTION

# SECTION 334100 – STORM DRAINAGE & PIPING

## PART 1 GENERAL

1.1 Scope:

A. Related work specified elsewhere:

1. Earthwork (Section 31 20 00)
2. Erosion & Sediment Control (Section 31 10 10)

1.2: Work included in this Section:

1. Installation of Storm Drainage Structures and Piping.
2. Temporary Protection of Work in progress.
3. Intermediate and As-Built Survey of the entire Storm Drainage System.

1.3: Industry Standards:

A. Reference: Some products and execution are specified in this section by reference to published specifications or standards of the following with respective abbreviations used:

1. The American Society for Testing and Materials (ASTM)
2. North Carolina Roadway Standard Drawings (most recent edition)
3. North Carolina Department of Transportation (NCDOT) Standards Specifications for Roads and Structures, latest edition.

B. Manufacturers: For purposes of designating type and quality for the work under this section, the drawings and these specifications are based on products manufactured or furnished by manufacturers or suppliers listed. Products of the following manufacturers will be acceptable if equal to those specified herein and, on the drawings, when approved in writing by the Engineer/Landscape Architect:

1. Grates & Frames:

(a) East Jordan Ironworks
(b) McKinley Ironworks
(c) Neenah Foundry

2. Plastic Drainage Pipe:

(a) ADS, Advanced Drainage Systems, Inc.
(b) Crumpler Plastic Pipe, Inc.
(c) Hancor, Inc.

C. City of Raleigh and Standards and Requirements: All storm drainage installation shall meet or exceed the City of Raleigh published requirements and standards.

D. Intermediate and As-Built Survey for Storm Drainage System and Storm-water Control Measures (SCM): <u>This Contractor shall provide an intermediate survey locating all pipes and storm drainage inlets showing pipe slopes and inverts for review by the Engineer/Landscape Architect prior to completion of finish grading.</u>

This Contractor shall also provide a Professional Land Surveyor (PLS) certified 'As-Built' survey of the complete storm drainage system at project's end.

PART 2 PRODUCTS

1.4: Storm System Materials:

A. Concrete: See Section 32 13 13 for concrete requirements; Standard weight, with minimum compressive strength of 3,000 psi at 28 days.

B. Masonry Mortar: Type "M" mortar complying with requirements of ASTM C 270-73. Mortar shall consist of 1 part Portland cement, 1/4 part hydrated lime, and 2 parts sand.

C. Brick: Standard weight concrete masonry units, modular size, conforming to ASTM C 55-71, Grade N-1.

D. Concrete Pipe: Modified tongue and grooved.

1. Reinforced: ASTM C-76, Class III.

2. Fittings: Pre-formed gasket joints complying with AASHTO M-198-B and federal specification number SS-SO-0021A.

E. Rip-Rap: See Section 1042 of NCDOT Specifications for Class stone noted.

F. Drainage Stone: hard, durable, uncoated gravel or crushed stone conforming to ASTM C 33-71a. Size of aggregate shall conform to NCDOT standard size #57M.

G. Polyvinyl Chloride (PVC) Piping and Fittings: PVC pipe and fittings shall be rigid type PSP, SDR35 meeting ASTM D3033 or type PSM, SDR35, meeting ASTM D3034. The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, wrinkles, dents and ultraviolet discoloration. All pipe shall be continuously and permanently marked with manufacturer's name or trademark, schedule and size of pipe.

H. Drainage steps: Steps are to be manufactured from high tension iron which has a min. tension strength of 35,000 lbs. per square inch with scored tread to meet safety requirements, similar or equal to Neenah #R-1980-O or ½" grade 60 steel coated with copolymer poly-propylene plastic meeting ASTM-C-478, ASTM D-4101, ASTM A-615 and AASHTO-M-199.

I. Cast Iron Grates, Frames, and Lids: See details on drawings; Neenah catalog #'s used; other equal manufacturers accepted.

J. Cast Iron Roof Drainage Adapter: Submit cut sheets and manufacturers specifications for the cast iron drainage adapters (boots) similar or equal to Neenah #R-4926-29 Series Downspout Shoes (Rainwater Leaders), compatible with sizes and materials used for roof drain downspouts. Submit no-hub coupling for connection to PVC pipe. Obtain approval of submittals from Engineer/Landscape Architect prior to purchase and installation. See Plans for the locations of downspouts.

K. Corrugated Plastic Pipe (CPP) (if required): Perforated, corrugated, black polyethylene drainage tubing with pre-manufactured “snap-tite” joints and protective geotextile fabric sleeve. See acceptable manufacturers listed in 1.2., b. (2) above.

L. Magnetic Locator Tape: This tape shall be 4” wide minimum. Submit for review and approval prior to purchase and installation.

1.5: Structures:

A. All storm structures shall be as per details on the drawings and in accordance with the City of Raleigh and NCDOT standards.

B. Pre-fabricated concrete boxes meeting all NCDOT and project requirements will be an acceptable substitute for “in place” masonry construction if submitted for review and approval by Engineer/Landscape Architect according to the Contract requirements.

PART 3 EXECUTION

3.1 Trenching:

C. Trenches shall not be excavated wider than necessary to work safely and efficiently. The minimum trench width at the top of the pipe shall be at least 18" greater than the outside diameter of the pipe. Excavate bottom of trench to fit curve of pipe. Trenches shall have uniform slope to accommodate the storm drainage lines as designed.

D. The bottom of the trench shall be solid, compacted earth. If the trench is inadvertently cut too deep, or soft spots are encountered, bring the bottom of the trench to grade using well tamped, fine crushed stone or compacted.

E. See plans for location and details for Groundwater Intercept Drains (if used). Refer to soils report for information addressing ground water on the site.

F. Slopes: Invert elevations shall take precedence over percentage slopes indicated. No pipes may be installed at less than three-quarter percent (one foot per 75 feet) gradient. Notify the Engineer/Landscape Architect if any inverts indicated and distances between drainage structures that require a gradient less than 3/4%.

G. Protect trench slopes. No standards less than OSHA will be accepted for benching as required.

H. Install magnetic locator tape at all underground non-metallic pipe installations. This tape shall be buried at a depth of 12 inches below the top surface of earth and 12 inches below top of subgrade at pavement and walks.

1.6: Laying Pipe:

A. When laying pipe, the bottom of the trench shall not be more than 0.02 feet (+ or - 1/4") from the precise grade at any point. Do not complete excavation of any trenches in which pipe cannot be laid the same day. Lay all pipe on a true line and grade using proper equipment for the situation. Inverts indicated have priority over slopes indicated.

B. All joints shall be laid with pre-formed plastic gaskets.

C. Each joint of pipe shall set on a solid bed to prevent settlement according to NCDOT standard specifications.

D. Install temporary cap-plug in end of pipe when work is temporarily halted.

1.7: Drainage Structures:

A. Curb inlets, junction boxes, drain inlets and other structures shall be constructed as detailed and specified herein or as per approved shop drawings.

B. All frames shall be set in a full bed of mortar as detailed. Minimum 0.5"depth.

C. Locations shall be coordinated with adjacent improvements and properly aligned for curbs or walks involved.

D. Inlet and outlet pipes shall be extended through the inlet box wall for sufficient distance beyond the outside surface to allow for connections, and the masonry around them shall be constructed neatly, so as to prevent leakage along their outer surface.

E. No pipes, cables or other structures shall be built into or through these structures except the attendant drainage pipes.

F. Form inverts in the bottom as detailed or as required by the City of Raleigh/NCDOT.

1.8: Inspection:

A. The Contractor shall notify the Engineer/Landscape Architect in ample time to permit inspection of assembled underground piping before backfilling is to begin.

B. The Contractor shall be prepared to remove any grates or manhole lids if requested by the Owners' Representative to allow for visual inspection of basin bottoms.

C. The Contractor shall flush out all storm drain lines of any sediment buildup prior to final inspection by Engineer/Landscape Architect and acceptance by the Owner.

D. The Contractor shall provide an adequate light source at the end of each line segment to permit visual inspection from the other end.

1.9: Storm Drainage System Certification:

A. This Contractor shall secure the services of a NC Registered Professional Land Surveyor (PLS) to survey and certify the as-built Storm Drainage system installation. The certification shall be done in the following steps:

1. After all storm drain lines are in place, the PLS shall survey the inverts and locations of all pipes and certify the inverts and pipe sizes are as required on the plans and meet the standards of these specifications. Any inverts or pipe sizes that do not meet these standards MUST be removed and reinstalled to meet these standards.

2. As soon as finished grades are established, and grate and frames are installed, the PLS shall survey the rim elevations and certify the rim elevations are as required on the plans and meet the standards of these specifications.

B. Have the Professional Land Surveyor complete the as-built survey and certification as described above.

C. Submit PLS certified surveys to the Engineer/Landscape Architect for total system certification of the storm system and basin to the Town of Car.

D. The Contractor is responsible for submitting the certification package to the City of Raleigh for the complete site storm drainage system. This includes but not limited to any certifications in order to close out any permits.

END OF SECTION 334100

APPENDIX

GEOTECHNICAL REPORT

FROEHLING & ROBERTSON, INC.

# Report of Subsurface Exploration and Geotechnical Engineering Evaluation

***NCDA&CS – Eaddy Building Addition***
*Raleigh, North Carolina*
*F&R Project No. 66A-0194*

Prepared For:
**Dewberry**
*2610 Wycliff Road, Suite 410*
*Raleigh, North Carolina 27607*

Prepared By:
***FROEHLING & ROBERTSON, INC.***
*310 Hubert Street*
*Raleigh, North Carolina 27603*

*February 9, 2023*

FROEHLING & ROBERTSON

*Engineering Stability Since 1881*

February 9, 2023

Leigh-Ann Dudley, PE
Associate, Senior Project Manager
Dewberry
2610 Wycliff Road, Suite 410
Raleigh, North Carolina 27607

**Subject: Report of Subsurface Exploration & Geotechnical Engineering Evaluation**
**NCDA&CS – Eaddy Building Addition**
Raleigh, North Carolina
F&R Project No. 66A-0194

Dear Ms. Dudley:

Froehling & Robertson, Inc. (F&R) has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed NCDA&CS – Eaddy Building Addition in Raleigh, North Carolina. Our services were performed in general accordance with F&R Proposal No. 2266-00223 dated August 30, 2022. The attached report presents our understanding of the project, reviews our exploration procedures, describes existing site and subsurface conditions, and presents geotechnical engineering recommendations for project design and construction.

We have enjoyed working with you on this project. Please contact us if you have any questions regarding this report or if we may be of further service.

Sincerely,

**FROEHLING & ROBERTSON, INC.**

Erin Benson

Erin Benson, E.I.
Geotechnical Engineering Staff

NORTH CAROLINA PROFESSIONAL SEAL 029927 ENGINEER Michael S. Sabodish, Jr

Michael S. Sabodish Jr. 2023.02.09 12:10:01 -05'00'

Michael S. Sabodish Jr., Ph.D., P.E.
Geotechnical Dept. Manager

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GBA Document "Important Information about Your Geotechnical Engineering Report"

# EXECUTIVE SUMMARY

***This Executive Summary is provided as a brief overview of our geotechnical engineering evaluation for the project and is not intended to replace more detailed information contained elsewhere in this report. As an overview, this summary inherently omits details that could be very important to the proper application of the provided geotechnical design/construction recommendations. This report should be read in its entirety prior to implementation into design and construction.***

- *The subsurface exploration consisted of six (6) soil test borings (B-1 through B-6) to depths ranging from 10.0 to 25.0 feet below the existing ground surface.*
- *Fill or possible fill soils were encountered in all of the borings from just below the surficial materials to depths typically ranging from 2.0 to 8.5 feet. The fill or possible fill consisted of medium dense clayey sand (USCS – SC) with an SPT N-value of 11 blows per foot (bpf), firm to stiff high plasticity clays and silts (USCS – CH and MH) with SPT N-values ranging from 6 to 14 bpf, and firm sandy clay (USCS – CL) with an SPT N-value of 5 bpf. The fill soils typically appeared to be moderately to well-compacted. Some of the fill materials contained varying amounts of deleterious materials including roots, gravel, and surficial organic soils in the upper 8.5 feet, which indicates that these materials may not be a structural fill material and may indicate the fill was placed and compacted without using formal construction earth filling techniques. Given the presence of deleterious materials, some of the fill may need to be undercut. It is recommended that further evaluation of the fill soils be performed at the time of construction to better estimate the extent of existing fill material that may require removal (undercutting) and replacement with new structural fill during site grading and foundation construction.*
- *The residual soils consisted of firm to very stiff, high plasticity sandy silts and clays (USCS – MH and CH) with SPT N-values ranging from 7 to 20 bpf and firm to very stiff, low plasticity sandy silts (USCS – ML) with SPT N-values ranging from 6 to 16 bpf. Highly plastic silts and clays were encountered in four (4) borings typically from just below the fill or possible fill soils and extended to 13.5 feet in the soil profile, with an average layer thickness of roughly 6.0 feet.*
- *Most of the recovered soil samples were observed to be in a moist condition; wet soils were encountered in two (2) borings at 6.5 to 18.5 feet and extended to the boring termination depth. The borings did not encounter stabilized groundwater. Based on the observed groundwater conditions, it is not generally anticipated that groundwater will be encountered during mass grading activities.*
- *The subsurface conditions revealed by the borings are typical of this area and do not pose significant geotechnical constraints to this project. Medium dense and/or stiff native soils and properly-compacted structural fill should be suitable to provide support for the structures on conventional foundations and stable subgrades for pavements.*
- *Stiff and medium dense native soils and properly compacted structural fill are suitable to support the proposed structures on shallow spread foundations designed using a net allowable bearing capacity of 2,000 psf.*

- *The lower plasticity soils (USCS – CL, ML, and SC) encountered in the borings are generally considered fair to good materials for use as structural earth fill and are suitable subgrades for slabs and pavements. The highly plastic silts and clays (USCS – MH and CH) are generally considered poor material for use as structural fill and poor material for direct support of building foundations, slabs, and roadways. The higher plasticity soils can be more difficult to properly place and compact and it is generally recommended that they be used in non-load bearing areas or in the lower portion of deeper fills provided they can be properly placed and compacted. If highly plastic soils are present at finished subgrade, undercutting and repair may be recommended.*
- *Due to the presence of highly plastic soils in various soil strata, subgrade repairs are likely to be required throughout the project site. Depending on the time of year when site grading takes place, moisture conditioning will likely be required (i.e., drying of wet soils). These practices are typical at projects in this geologic area. Due to the moisture sensitivity of the soils, it is recommended that earthwork activities be performed during the seasonally dryer months (typically May to October) when weather conditions are most conducive to moisture conditioning and performing subgrade repairs.*

## 1.0 PURPOSE & SCOPE OF SERVICES

The purpose of the subsurface exploration and geotechnical engineering evaluation was to explore the subsurface conditions in the area of the proposed building addition and loading dock expansion and to provide geotechnical engineering recommendations that can be used during the design and construction phases of the project.

F&R's scope of services included the following:

- Completion of six (6) soil test borings (B-1 through B-6) to depths ranging from 10.0 to 25.0 feet below the existing ground surface;
- Performing geotechnical laboratory testing on representative soil samples;
- Preparation of typed Boring Logs and a Subsurface Profile;
- Performing a geotechnical engineering evaluation of the subsurface conditions with regard to their suitability for the proposed construction; and
- Preparation of this geotechnical report by a professional engineer.

## 2.0 PROJECT INFORMATION

### 2.1 SITE LOCATION AND DESCRIPTION

The project site is located at the existing North Carolina Department of Agriculture building addressed as 4300 Reedy Creek Road in Raleigh, North Carolina (see Figure No. 1 in Appendix I). More specifically, the area of the proposed building addition is located at the northeast corner of the existing building and the area of the proposed loading dock expansion is located on the east side of the existing building. Within the areas of our exploration, the site consists of landscaped open grass-covered areas on the east side of the existing building in the area of the proposed building addition and a concrete surfaced loading area in the area of the proposed loading dock expansion. Additionally, an existing soil stockpile is present on the northeast corner of the site within the area of the proposed building construction.

Based on a review of the provide plans, the grassed area just east of the existing building, where the new building addition is proposed, slopes down from the existing asphalt parking lot at EL 443 towards the northeast corner of the proposed building to EL 441.

## 2.2 PROPOSED CONSTRUCTION

Based on the drawing titled "Eaddy Building Addition" prepared by Hobbs Architects, PA and dated November 11, 2022, the building addition will have a footprint of 65.0 by 82.0 feet (5,330 square feet) and will primarily contain storage space for soil samples. The single-story building addition will be located on the northeast corner of the existing NCDA building and mechanical courtyard and will also contain a laboratory, bathroom, office, and maintenance shop. The single-story building addition will be a slab-on-grade structure with a steel frame and metal cladding. F&R assumes that wall and column loads will be less than about 3 kips per linear foot and 50 kips, respectively. It is anticipated that most wall and column foundations will typically bear 2.0 to 3.0 feet below the Finished Floor Elevation (FFE). Existing site grades within the limits of the proposed building addition are set at approximately EL 441 to EL 443. As such, earth fills of roughly 1.0 to 3.0 feet will be required to establish the proposed finished floor elevation of EL 443..

In addition, the proposed construction includes extending the existing loading dock and continuing a 10-foot wide covered loading dock/walkway from the existing building to the new building. The loading dock expansion and walkway will extend south along the west side of the new building, and then turn west around the mechanical yard to the existing loading dock. Based on the provided plans, the grade of the proposed loading dock expansion will match the existing loading dock, which is set at EL 447. F&R assumes the canopy column loads will be less than 20 kips.

# 3.0 EXPLORATION PROCEDURES

## 3.1 SUBSURFACE EXPLORATION

F&R advanced a total of six (6) soil test borings (B-1 through B-6) to depths ranging from 10.0 to 25.0 feet below the existing ground surface. The SPT borings were advanced at the approximate locations shown on the Boring Location Plans presented as Figures No. 2 and 2A in Appendix I. The test boring locations were established in the field by F&R using a hand-held GPS unit with reported sub-meter accuracy. Ground surface elevations at the boring locations were interpolated from the provided "Topographic Survey" drawings. Given these methods of determination, the boring locations and ground surface elevations should only be considered approximate.

The test borings were advanced by an ATV-mounted drill rig using 2-1/4" inside diameter (I.D.) hollow stem augers for borehole stabilization. Representative soil samples were obtained using a standard two-inch outside diameter (O.D.) split barrel sampler in general accordance with ASTM D 1586, Penetration Test and Split-Barrel Sampling of Soils (Standard Penetration Test - SPT). The number of blows required to drive the split barrel sampler three, consecutive 6-inch increments with an automatic hammer is recorded, and the blows of the last two 6-inch increments are added to obtain the SPT N-values representing the penetration resistance of the soil. Five (5) SPT samples were collected in the top 10.0 feet and then at a nominal interval of 5.0 feet thereafter.

A representative portion of the soil was obtained from each SPT sample, sealed in an eight-ounce glass jar, labeled, and transported to our laboratory for classification and analysis by a geotechnical engineer. The soil samples were classified in general accordance with the Unified Soil Classification System (USCS), using visual-manual identification procedures (ASTM D2488). A Boring Log for each test boring is presented in Appendix II.

Groundwater level measurements were attempted at the termination of drilling and after a stabilization period of approximately 24-hours following the completion of drilling in all of the borings. Temporary piezometers were installed in borings B-1 and B-5 to facilitate the measurement of stabilized groundwater levels. The temporary piezometers consisted of 1-inch diameter, hand-slotted PVC pipe installed into the completed borings. Following the collection of the stabilized groundwater readings, the temporary piezometers were removed from the borings, and all of the boreholes were backfilled with soil cuttings.

### 3.2 Laboratory Testing

F&R selected four (4) representative soil samples and subjected them to routine geotechnical index testing consisting of Natural Moisture Content, Sieve Analysis (% passing the #200 sieve), and Atterberg Limits determinations. The purpose of the index testing was to aid in our classification of the soil samples and development of engineering recommendations. The laboratory testing was performed in general accordance with applicable ASTM standards. The laboratory test results are presented in Appendix III of this report.

# 4.0 REGIONAL GEOLOGY & SUBSURFACE CONDITIONS

## 4.1 Regional Geology

The project site is geologically located in the Piedmont Physiographic Province of North Carolina. The Piedmont Province region generally consists of hills and ridges that are intertwined with an established system of draws and streams. According to our review of the 1985 Geologic Map of North Carolina, published by the Department of Natural Resources and Community Development, the site is geologically located within the Raleigh Belt with bedrock materials consisting of felsic mica gneiss. These materials were deposited during the Cambrian to Late Proterozoic Period. The bedrock materials have weathered in place to form the residual soils which are typically found near the ground surface of the site.

The virgin soils encountered in this area are the residual product of in-place chemical weathering of rock that was similar to the rock presently underlying the site. In areas not altered by erosion or disturbed by the activities of man, the typical residual soil profile consists of clayey soils near the surface, where soil weathering is more advanced, underlain by silts, sandy silts, and silty sands above partially weathered rock and bedrock. The boundary between soil and rock is not sharply defined. This transitional zone termed Partially Weathered Rock (PWR) is typically found overlying the parent bedrock. PWR is defined, for engineering purposes, as material exhibiting Standard Penetration Resistances in excess of 100 blows per foot (bpf). Weathering is facilitated by fractures, joints and by the presence of less resistant rock types. Consequently, the profile of the partially weathered rock and hard rock is quite irregular and erratic, even over short horizontal distances. PWR was not encountered during our exploration.

## 4.2 Subsurface Conditions

### 4.2.1 General

The subsurface conditions discussed in the following paragraphs and those shown on the attached boring logs represent an estimate of the subsurface conditions based on interpretation of the boring data using normally-accepted geotechnical engineering judgments. Although individual soil test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. Data from the specific soil test borings are shown on the boring logs presented in Appendix II of this report.

A subsurface profile has been prepared from the boring data to graphically illustrate the subsurface conditions encountered at the site. The subsurface profile is presented as Figure No. 3 in Appendix I. Strata breaks designated on the boring logs and subsurface profile represent approximate boundaries between soil types. The transition from one soil type to another may be gradual or occur between soil samples. This section of the report provides a general discussion of subsurface conditions encountered within areas of proposed construction at the project site. More detailed descriptions of the subsurface conditions at the individual boring locations are presented on the boring logs provided in Appendix II.

### 4.2.2 Surficial Materials

Surficial organic soils were encountered in five (5) borings (B-1 through B-5) from the existing ground surface to depths ranging from 0.2 to 0.3 feet. The surficial organic soils generally consisted of dark-colored soil material containing roots and/or other organic components, and is generally unsuitable for engineering purposes.

F&R has not performed any laboratory testing to determine the organic content or other horticultural properties of the observed surficial organic soil materials. Therefore, the term "Surficial Organic Soil" are not intended to indicate suitability for landscaping and/or other purposes. It should be noted that the surficial organic soil depths provided in this report are based on driller observations and should be considered approximate. We note that the transition from surficial organic soil to underlying materials may be gradual, and therefore the observation and measurement of the surficial organic soil depths is subjective. Actual surficial organic soil depths should be expected to vary.

Boring B-6, which is located within the area of the proposed loading dock addition east of the existing building, encountered a 7 inch layer of concrete underlain by a 4 inch layer of aggregate base course (ABC).

### 4.2.3 Fill and Possible Fill Soils

Fill and possible fill soils were encountered below the surficial materials in all of the borings to depths ranging from 2.0 to 8.5 feet, and are likely related to previous site grading activities for the existing building. It is noted that sometimes the relatively small and disturbed sample obtained in the field is insufficient to definitively describe the origin of the subsurface material. Since man-made materials, deleterious materials, or other obvious evidence of fill were not encountered in the soil samples that appeared to be earth fill, some of the materials believed to be earth fill are referred to as "possible fill". The fill and possible fill soils consisted of medium dense clayey sand (USCS – SC) with an SPT N-value of 11 blows per foot (bpf), firm to stiff high plasticity clays and silts (USCS – CH and MH) with SPT N-values ranging from 6 to 14 bpf, and firm sandy clay (USCS – CL) with an SPT N-value of 5 bpf. Varying amounts of fine to coarse gravel were encountered in some of the borings and a 1.5 foot layer of possible surficial organic soil was encountered in boring B-1 from 6.5 to 8.0 feet. Root fibers were encountered in a majority of the borings from just below the surficial soils to depths ranging from of 6.5 to 11.5 feet.

Fill and possible fill soils exhibiting SPT N-values of 4 bpf or less are generally indicative of fill with poor compaction while fill soils exhibiting SPT N-values of 5 to 8 bpf are generally indicative of fill with moderate compaction. Well-compacted fill that does not contain gravel or deleterious materials, would typically exhibit SPT N-values of 9 bpf or higher. In general, it appears that the fill was moderately to well-compacted. However, it should be noted that the presence of gravel likely amplified the SPT N-values, and as such, may not reflect the true consistency of the fill.

#### 4.2.4 Residual Soils

Extending below the surficial materials, fill, and/or possible fill soils, the borings encountered residual soils. The residual soils typically consisted of firm to very stiff, high plasticity sandy silts and clays (USCS – MH and CH) with SPT N-values ranging from 7 to 20 bpf and firm to very stiff, low plasticity sandy silts (USCS – ML) with SPT N-values ranging from 6 to 16 bpf. Highly plastic residual silts and clays were encountered in four (4) borings (B-1, B-2, B-3, and B-5) typically from just below the fill or possible fill soils and extended to 13.5 feet in the soil profile, with an average layer thickness of approximately 6.0 feet.

### 4.3 Soil Moisture and Groundwater Conditions

Most of the soil samples from the borings were observed to be in a moist condition (i.e., within 3 to 5 percentage points of the estimated optimum moisture content). Wet soils (5 to 6 percentage points or greater over the estimated optimum moisture content) were encountered in borings B-2 and B-3 at a depth of 18.5 and 6.5 feet, respectively, and extended to the boring termination depth.

Groundwater level measurements were attempted at the termination of drilling in all of the borings and after a stabilization period of approximately 24-hours following the completion of drilling. However, groundwater was not encountered in any of the borings. Borehole cave depths were recorded in the borings without temporary piezometers immediately after drilling and approximately 24-hours following the completion of drilling, and can sometimes be an approximate indicator of the groundwater table. Caving of the borehole was encountered in the borings at depths ranging from about 7.8 to 23.3 feet below the existing ground surface.

Due to the presence of relatively impervious soils on the project site, trapped or perched water conditions should be anticipated during periods of inclement weather and during seasonally wet periods. It should be noted that the groundwater levels fluctuate depending upon seasonal factors such as precipitation and temperature. As such, soil moisture and groundwater conditions at other times may vary from those described in this report.

## 5.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

### 5.1 GENERAL GEOTECHNICAL CONSIDERATIONS

The conclusions and recommendations contained in this section of the report are based upon the results of the six (6) test borings, laboratory testing performed by F&R, our experience with similar subsurface conditions and projects, and the information provided regarding the proposed development. It is our opinion that the subsurface conditions encountered at the project site are suitable for the proposed development from a geotechnical engineering perspective provided the recommendations presented in subsequent sections of this report are followed throughout the design and construction phases of this project. As the project design progresses, F&R requests an opportunity to review project plans and specifications to confirm that the recommendations presented in this report have been properly interpreted and implemented, and to determine if additional geotechnical exploration and/or recommendations are warranted.

Stiff or medium dense native soils and properly placed and compacted structural fill should be suitable for support of the proposed structure on conventional shallow spread foundations that are sized for a net allowable soil bearing capacity of 2,000 psf. Certain subsurface conditions revealed during the explorations will impact site development and grading activities, and should be considered during the planning and design phases of this project. As such, allowances should be made in the construction documents for various subgrade repair procedures, quantities and materials.

The subsurface conditions of particular note include the following:

**EXISTING FILL AND POSSIBLE FILL:** Existing and possible fill soils were encountered in the borings advanced within the proposed building and loading dock expansion to depths ranging from 2.0 to 8.5 feet below existing ground surface. Most of the fill and possible fill material was sampled as highly plastic soils (CH and MH) and encountered varying amounts of deleterious material including fine to coarse gravel and a 1.5 foot layer of possible surficial organic soil in boring B-1 from 6.5 to 8.0 feet. The fill appeared to be moderately to well compacted with SPT N-values ranging from 6 to 14 bpf although, it is noted that these values may have been elevated due to the gravel content and may not reflect the true consistency of the existing fill. As such, the presence of these deleterious materials likely indicate the fill may not have been placed and compacted using formal construction techniques. F&R recommends that further evaluation be performed to assess the extent, composition, and consistency of the fill in the purposed building and loading dock expansion. This evaluation may include proofrolls, additional test pits, or hand auger borings. Due to the composition and type of fill soils (highly plastic CH & MH soils) encountered, it is anticipated that at least some of the existing fill soils at the purposed building and loading dock expansion will not be considered suitable for support of the building due to the potential for adverse settlement. Based on the results of the additional evaluation, it may be recommended that some or all of the old fill in this area be removed within the building footprint. Some modification will likely need to be made at the time of construction depending on the conditions encountered, but it is anticipated that at least some of old fill will need to be undercut and replaced. F&R recommends the existing fill area be evaluated by the geotechnical engineer and any necessary repairs performed prior to placement of new structural fill and foundations, to establish finished grades.

**HIGHLY PLASTIC SOILS (MH & CH):** Highly plastic fill soils (MH and CH) were encountered in all of the borings. In addition, highly plastic residual soils (MH and CH) were encountered in the area of borings B-1, B-2, B-3, and B-5 below the fill and/or possible fill soils. These highly plastic soils are generally considered poor material for use as structural fill and poorer subgrade materials for foundations, slabs, and pavements. If present at finished subgrade, undercutting and repair or other methods of ground improvement may be recommended. The higher plasticity soils are moisture sensitive and can undergo volume changes (shrink/swell) and loss of strength with fluctuations in moisture content. As a result, the higher plasticity soils can be more difficult to properly place and compact and can become unstable during normal construction activities when wet. When these soils are present at finished subgrade (e.g., roadway and building subgrades), undercutting and repair with lower plasticity materials is generally recommended to create suitable subgrades for pavement and building construction.

## 5.2 FOUNDATION DESIGN RECOMMENDATIONS

The project site is suitable to support the proposed structures on conventional shallow spread foundations provided the site preparation and fill placement recommendations presented in this report are followed. As previously indicated, existing fill and residual materials which were determined to be highly plastic were encountered in the area of the building addition and loading dock expansion and may require undercutting and repair in order to create a stable subgrade to support the floor slabs and foundations. Further evaluation of the fill material should be performed at the time of construction under the direction of the geotechnical engineer.

For foundations bearing on stiff/medium dense native soils or properly compacted structural fill overlying approved native materials, F&R recommends the use of a net allowable soil bearing pressure of 2,000 pounds per square foot (psf) for the design of foundations. It appears the new building and loading dock expansion foundations will bear in new structural fill within 2.0 to 3.0 feet of existing site grades or in existing fill soils if approved by the geotechnical engineer. Spread foundations should bear directly upon approved structural fill and should be embedded at least 24 inches below adjacent exterior grades for bearing capacity and frost protection considerations. Wall foundations should have a minimum width of at least 2.0 feet and column foundations should have a minimum width of at least 3.0 feet. Final foundation sizes should be determined by the project structural engineer based on actual design loads, building code requirements and other structural considerations.

For foundations designed and constructed in accordance with the recommendations provided in this report, we have estimated that maximum total settlements for the provided 50 kip maximum column loads will be on the order of 1 inch or less. Differential settlements for all foundation types are expected to be on the order of approximately 0.5 inches or less. We anticipate that such settlements will be structurally acceptable; however, this should be verified by the project structural engineer.

### 5.3 Slab-on-Grade Floors

F&R understands the floor will be designed as a slab-on-grade. We recommend that a modulus of subgrade reaction (k) of 125 pounds per cubic inch (pci) be used for slab design. The subgrade soils for support of floor slabs should be prepared as outlined in subsequent sections of this report. The floor slab should be supported on at least 4 inches of NCDOT #57 to provide a uniformly well-compacted material immediately beneath the slab. The floor slab should be underlain by a vapor retarder to reduce the potential for floor slab dampness. Vapor retarder construction should be performed in accordance with applicable ACI guidelines.

Floor slab design and construction should incorporate isolation joints around columns, utility penetrations, and along bearing walls to allow for differential movement to occur without damage to the floor. Final slab design should be determined by the project structural engineer based on actual design loads, building code requirements and other structural considerations.

## 5.4 Retaining Walls

### 5.4.1 General

Based on the provided plans, F&R assumes a cast-in-place concrete retaining wall is planned for supporting the loading dock expansion and walkway to the proposed building addition. This L-shaped retaining wall will have a height of approximately 4.0 feet and an approximate length of 80.0 feet. Construction of this retaining wall will require soil backfill depths of 3.0 to 4.0 feet above existing ground surface to establish proposed site grades.

For foundations bearing on stiff/medium dense native soils or properly compacted structural fill overlying approved native materials, F&R recommends the use of a net allowable soil bearing pressure of 2,000 pounds per square foot (psf) for the design of the retaining wall foundations.

### 5.4.2 Cast-in-Place Loading Dock Retaining Walls

As previously mentioned, cast-in-place concrete loading dock retaining walls will be constructed on the south and east sides of the existing building with a walkway to the proposed building addition. Laterally loaded walls that are restrained from movement, such as loading dock walls, should be designed based on at-rest lateral earth pressures. If low plasticity silts and clays or sandy soils are used to backfill the walls, the walls should be designed using an at-rest coefficient (Ko) of 0.53. Assuming a moist backfill unit weight of 120 pounds per cubic foot (pcf), F&R recommends that an at-rest earth pressure equivalent fluid weight (EFW) of 63.7 pcf be used in design. Highly plastic silt or clay soils should not be used as backfill for retaining walls.

Lateral earth pressures arising from surcharge loading, foundations in the backfill zone, earthquake loading and groundwater should be added to the above soil earth pressures to determine the total lateral earth pressure, which the walls must resist. In addition, transient loads imposed on the walls by construction equipment during backfilling should be taken into account during design.

Compaction of backfill behind the walls should be at least 95 percent of the Standard Proctor maximum dry density in structural areas. In non-structural areas, backfill compaction can be reduced to 92 percent. Excessive compaction may cause damage to the walls. Walls should be adequately braced during compaction of the wall backfill. Heavy compaction equipment should not be allowed within 10.0 feet of the walls.

### 5.5 Protection of Existing Structures

As previously mentioned, the proposed building addition will be situated roughly 10.0 feet southeast of the existing mechanical courtyard. Based on anticipated excavation depths of EL 440, the site grades will need to be lowered adjacent to the existing structures by up to about 4.0 feet. These excavation depths may extend below the foundations of the existing structures. In addition, based on the anticipated FFE of 443, fill depths ranging from about 1.0 to 3.0 feet may be necessary on the northeast side of the building. Therefore, additional settlement could occur beneath the perimeter wall foundations of the existing building due to the added stress from the fill and new foundations. Efforts should be implemented so as not to jeopardize the integrity of the structures during construction and for the life of the structures. Such efforts could include underpinning the existing structures, or designing a shoring/retaining system to account for the loading from the structures.

### 5.6 Site Seismic Classification

Our scope of services did not include site specific soil shear wave velocity testing and evaluation. F&R has evaluated the data obtained from the soil test borings for assignment of Seismic Site Class to this site. In accordance with procedures outlined in the 2018 NC Building Code for determining Site Class, a weighted average of the soil conditions in the upper 100 feet was performed using SPT N-values with the assumption that PWR may be encountered at a depth of 50 feet below the ground surface. **Based on this evaluation of the SPT N-values, the soil profile indicates a Site Class D is applicable to the project.**

It is noted that F&R has not performed an evaluation of liquefaction potential since this was not part of our scope work for the project. However, based on the soil type, consistency of the subsurface soils and groundwater conditions encountered, there does not appear to be a significant potential for liquefaction at this site based on the available boring data.

### 5.7 Cut and Fill Slopes

To establish finished grades at the proposed fill slope located to the northeast of the proposed building, fill depths of 2.0 to 3.0 feet will be required. Proposed slope grades were not available at the time of this report however, F&R recommends designing the permanent project slopes at 3H:1V or flatter for slopes less than approximately 15.0 feet in height. The tops of the slopes should be located a minimum of 10.0 feet from structural limits. The slopes should be constructed on subgrades approved by the geotechnical engineer. As previously indicated, existing fill soils that were observed to be highly plastic were encountered in the area of the proposed building. This fill may need to be removed and replaced with properly placed and compacted structural fill.

## 6.0 GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

### 6.1 General Site Preparation

Initial site preparation should include stripping of surficial organic soil and other deleterious materials from within the proposed development area. The resulting excavations should be backfilled with compacted, structural fill as recommended in a subsequent section of this report. It should be noted, as with any site adjacent to where previous construction has occurred, that there is some potential of encountering construction debris, unknown fills, or isolated soft soils in areas adjacent to the previous construction, in unexplored portions of the project, or in areas affected by demolition activities. As such, close observation of subgrade conditions should be performed across the site. Additionally, if any abandoned, open pipes or conduits are to be left in-place, they should be bulk-headed or grouted as they may serve as conduits for subsurface erosion. All surficial organic soils, vegetation, and other deleterious materials (including old soil stockpiles) should be stripped from the building and other load bearing areas. The stripping should extend a distance of at least 5.0 feet beyond the building perimeters, but not less than the area within a 2H:1V slope projecting down to original grade from the perimeter footings or building pad in fill areas, whichever is greater.

Following the stripping of materials from proposed structural areas, the exposed subgrade soils at the finished subgrade level and in fill sections should be proofrolled with a loaded, tandem-axle dump truck, scraper, or other similar type of construction equipment to give an indication as to the stability of the subgrade soils. The proofroll operations should be observed by a geotechnical engineer or their representative. If proofrolling reveals unstable conditions, the method of repair should be as directed by the project geotechnical engineer. Methods of repair may include, but are not necessarily limited to: drying and re-compaction; undercutting and replacement with suitable structural fill; use of geotextiles and/or geogrids with select fill; use of lime stabilization; or other methods deemed appropriate by the project geotechnical engineer.

As reported earlier in this report, existing fill and possible fill soils were encountered in all of the borings advanced during this assessment to depths ranging from 2.0 to 8.5 feet. The existing fill encountered within the proposed building addition encountered deleterious materials such as roots, surficial organic soils, and gravel. As such, the presence of these deleterious materials likely indicate the fill may not have been placed and compacted using formal construction techniques. Fill soils are likely to be encountered in other unexplored areas of the site. F&R recommends further evaluation of the fill should be performed at the time of construction and the exposed subgrade be evaluated by the geotechnical engineer prior to placement of new structural fill. This evaluation may include proofrolling with a loaded tandem axle truck, test pits, or hand auger borings. Based on the results of additional evaluation, it may be recommended that some or all of the old fill in these areas be removed and replaced with adequately compacted structural fill particularly if it contains deleterious materials similar to those encountered in the test borings.

As reported earlier, high plasticity soils (CH and MH) were encountered in all of the borings. These soils are highly moisture sensitive and can undergo volume changes (shrink/swell) and strength loss with changes in moisture content. These soils are generally considered to be poor subgrade materials. Due to the moisture sensitivity, shrink/swell potential, and poor subgrade/bearing grade characteristics, F&R recommends that a minimum of 1.5 feet of separation be maintained between stable high plasticity soils and proposed subgrades for pavement and building pad areas. In order to create this separation, undercutting of highly plastic soils and replacing with lower plasticity soils or NCDOT No. 57 washed stone wrapped in geotextile fabric may be required to establish suitable foundation bearing grades within the proposed building and loading dock expansion.

### 6.2 Structural Fill Placement and Compaction

It is expected that the low plasticity silts and clays and silty/clayey sands (CL, ML, SC, and SM) can be used as structural fill material. Low plasticity soils are generally considered fair to good materials for use as structural earth fill. Highly plastic soils (CH and MH) are considered poor materials for re-use as structural fill and it is recommended that they be used in non-load bearing areas. Due to the limited construction and grading proposed at the site, it is anticipated that the undercut highly plastic soils will likely need to be exported from the project site, and imported structural fill materials will be required to establish proposed site grades.

Although a grading plan was not available at the time of this report, it appears soils will need to be imported to the site to achieve finished grades. F&R recommends that a qualified geotechnical engineer or engineering technician working under the direction of the geotechnical engineer approve the suitability of the imported soils prior to their delivery to the site. Imported structural fill should consist of low plasticity soil (LL<35, PI<20), have a maximum dry density of at least 100 pcf, and be free or organic and other deleterious materials.

A majority of the recovered soil samples were typically described as dry to moist. Wet soils were encountered in two (2) borings at 6.5 and 18.5 feet. As such, it is anticipated that mostly dry and moist soil will typically be encountered during construction, and moisture conditioning (i.e., drying of wet soils, or wetting of dry soils) may be required in order to properly compact as structural fill.

Structural earth fill should be compacted at a moisture content within $\pm3$ percentage points of the optimum moisture content. All structural earth fill (*i.e.,* fill placed in load bearing areas or slopes) should be placed in loose lifts not exceeding 8 inches and be compacted to at least 95 percent of the

Standard Proctor maximum dry density as determined by ASTM D-698. The top 12 inches of fill should be compacted to at least 98 percent of the Standard Proctor maximum dry density. All areas requiring grade increases that are steeper than a slope of 4H:1V should be plowed, stepped and leveled to assure that fill is placed on near level surfaces. All structural fill material should be placed and compacted under the full-time observation of a qualified geotechnical engineer or engineering technician working under the direction of the geotechnical engineer. The placement and compaction of all structural fill should be observed on a full-time basis by a geotechnical engineer or qualified engineering technician working under the supervision of the geotechnical engineer, and all fill material should be tested at frequent intervals in order to confirm that the recommended degree of compaction is achieved.

As previously stated, the on-site soils have sufficient silt/clay content to render them moisture sensitive. The on-site soils will become unstable (*i.e.,* pump and rut) during normal construction activities when in the presence of excess moisture. Soils with a moisture content greater than 3 percentage points above the optimum moisture content are generally considered to have excessive moisture. During earthwork and construction activities, surface water runoff must be drained away from the construction areas to prevent water from ponding on or saturating the soils within excavations or on subgrades. This is especially important considering the moisture sensitivity of the soils at this site.

### 6.3 BUILDING AND LOADING DOCK FOUNDATIONS

Subsequent to bringing the site to finished grade levels in an approved manner, and repairing unsuitable earth fill, and native subgrade soils as previously discussed, the excavation of building and loading dock foundations may be initiated. We recommend that the footing excavations be observed by a qualified geotechnical engineer or their representative prior to placement of reinforcing steel and concrete. The purpose of the observation would be to determine that the foundations bear in suitable soils at the proper embedment depths, and that unsuitable soft or loose materials are undercut and backfilled with approved structural fill material. Hand auguring and Dynamic Cone Penetrometer (DCP) testing should be performed at the direction of the project geotechnical engineer to verify the consistency of the bearing soils and underlying support soils. It is recommended that a smooth bladed backhoe bucket be used to remove the final 6 to 12 inches of soils above the foundation bearing grade in order to prevent disturbing soils below the bearing grade and/or prevent gouging narrow grooves in the bearing grade as may occur with a toothed-end bucket.

F&R assumes the proposed foundation bearing grades for building and loading dock foundations will likely consist of existing fill soils, if approved by the geotechnical engineer, new structural fill, or residual soil. If foundation bearing grade undercutting is performed, the undercut excavations should be backfilled with materials approved by the project geotechnical engineer. Some undercuts may be recommended to be backfilled with NCDOT No. 57 washed stone up to the planned bearing grade. The washed stone thickness should not exceed 2.0 feet before the surface of the washed stone is densified with a heavy vibratory plate compactor to the satisfaction of the geotechnical engineer or his representative.

Exposure to the environment may weaken the soils at the footing bearing level if excavations remain open for long periods of time. The foundation bearing surface should be level or suitably benched and free of loose soil, ponded water and debris. If the bearing soils are softened by surface water intrusion or exposure, the softened soils must be removed from the foundation excavation immediately prior to placement of concrete. Foundation excavations must be maintained in a drained/de-watered condition throughout the foundation construction process. If the foundation excavations must remain open overnight, or if rainfall becomes imminent while the bearing soils are exposed, we recommend that a 2 to 4 inch thick "mud mat" of lean concrete (1,500 psi) be placed on the bearing soils before placing the reinforcing steel. In addition, F&R stresses the need for positive perimeter surface drainage around building areas to direct all runoff water away from buildings and foundations.

### 6.4 Floor Slab Construction

The subgrade soils for support of floor slabs should be prepared as outlined in previous sections of this report. Utility and other construction excavations performed in the prepared floor slab subgrade should be backfilled with properly compacted structural fill to aid in providing uniform slab support. Prior to base course placement, the subgrade should be evaluated by the project engineer and soft, wet, or otherwise unsuitable subgrade soils should be removed. To reduce the risks of unsightly slab cracking, F&R recommends that concrete quality control testing be performed during concrete placement, control joints (as designed by the structural engineer) be cut into the slab as soon as possible after the concrete placement, and the slab be cured as appropriate for the prevailing weather conditions.

### 6.5 SLOPE CONSTRUCTION RECOMMENDATIONS

Fill slopes should be prepared as outlined in sections 6.1 and 6.2 of this report. Fill slopes should be over built at least 1-foot and then cut back to assure the slope face is well compacted material. The slopes should be vegetated as soon as possible to minimize surface sloughing and erosion. However, seepage and surface runoff may cause the slopes to slough and erode resulting in shallow surface failures. A swale or shallow ditch should be constructed near the top of slopes to prevent surface water from flowing onto the slopes. We recommend that all cut and fill slopes be observed by a geotechnical engineer or their representative during construction. Additional slope drainage and protection measures may be required in certain areas depending upon conditions observed at the time of slope construction.

### 6.6 TEMPORARY EXCAVATION RECOMMENDATIONS

Mass excavations and other excavations required for construction of this project should be performed in accordance with the United States Department of Labor, Occupational Safety and Health Administration (OSHA) guidelines (29 CFR 1926, Subpart P, Excavations) or other applicable jurisdictional codes for permissible temporary side-slope ratios and/or shoring requirements. The OSHA guidelines require daily inspections of excavations, adjacent areas and protective systems by a "competent person" for evidence of situations that could result in cave-ins, indications of failure of a protective system, or other hazardous conditions. All excavated soils, equipment, building supplies, etc., should be placed away from the edges of the excavation at a distance equaling or exceeding the depth of the excavation. F&R cautions that the actual excavation slopes will need to be evaluated frequently each day by the "competent person" and flatter slopes or the use of shoring may be required to maintain a safe excavation depending upon excavation specific circumstances. The contractor is responsible for providing the "competent person" and all aspects of site safety. F&R can evaluate specific excavation slope situations if we are informed and requested by the owner, designer or contractor's "competent person".

## 7.0 CONTINUATION OF SERVICES

As previously discussed, the geotechnical engineer of record should be retained to observe and test earthwork activities, and subgrade preparations for slopes, foundations, floor slabs and pavements. It should be noted that the actual soil conditions at the various subgrade levels and footing bearing grades will vary across this site and thus the presence of the geotechnical engineer and/or their representative during construction will serve to validate the subsurface conditions and recommendations presented in this report.

We recommend that F&R be employed to monitor the earthwork and foundation construction, and to report that the recommendations contained in this report are completed in a satisfactory manner. Our continued involvement on the project will aid in the proper implementation of the recommendations discussed herein. The following is a recommended scope of services:

- Review of project plans and construction specifications to verify that the recommendations presented in this report have been properly interpreted and implemented;
- Development of allowance quantities for various anticipated subgrade repairs;
- Observe the earthwork process to document that subsurface conditions encountered during construction are consistent with the conditions anticipated in this report;
- Observe the subgrade conditions before placing structural fill including proofroll observations;
- Observe the placement and compaction of any structural fill and backfill, and perform laboratory and field compaction testing of the fill;
- Observe all foundation excavations and footing bearing grades for compliance with the recommended design soil bearing capacity to include conducting hand auger and DCP testing in the footing excavations in order to confirm the anticipated subsurface conditions and define footings that should be undercut and repaired as outlined in this report; and,
- Perform additional explorations, if considered necessary depending on finalized design considerations including building layout, finished grades and building loads.

## 8.0 LIMITATIONS

This report has been prepared for the exclusive use of Dewberry and/or their agents, for specific application to the referenced project in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made. Our evaluations and recommendations are based on design information furnished to us; the data obtained from the previously described subsurface exploration program, and generally accepted geotechnical engineering practice. The evaluations and recommendations do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to re-evaluate our recommendations based upon on-site observations of the conditions.

There are important limitations to this and all geotechnical studies. Some of these limitations are discussed in the information prepared by GBA, which is included in Appendix IV. We ask that you please review this GBA information.

Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should evaluate earthwork, pavement, and foundation construction to verify that the conditions anticipated in design actually exist. Otherwise, we assume no responsibility for construction compliance with the design concepts, specifications, or recommendations.

In the event that changes are made in the design or location of the proposed structures, the recommendations presented in the report shall not be considered valid unless the changes are reviewed by our firm and conclusions of this report modified and/or verified in writing. If this report is copied or transmitted to a third party, it must be copied or transmitted in its entirety, including text, attachments, and enclosures. Interpretations based on only a part of this report may not be valid.

# APPENDIX I

# FIGURES


# Site Vicinity Map

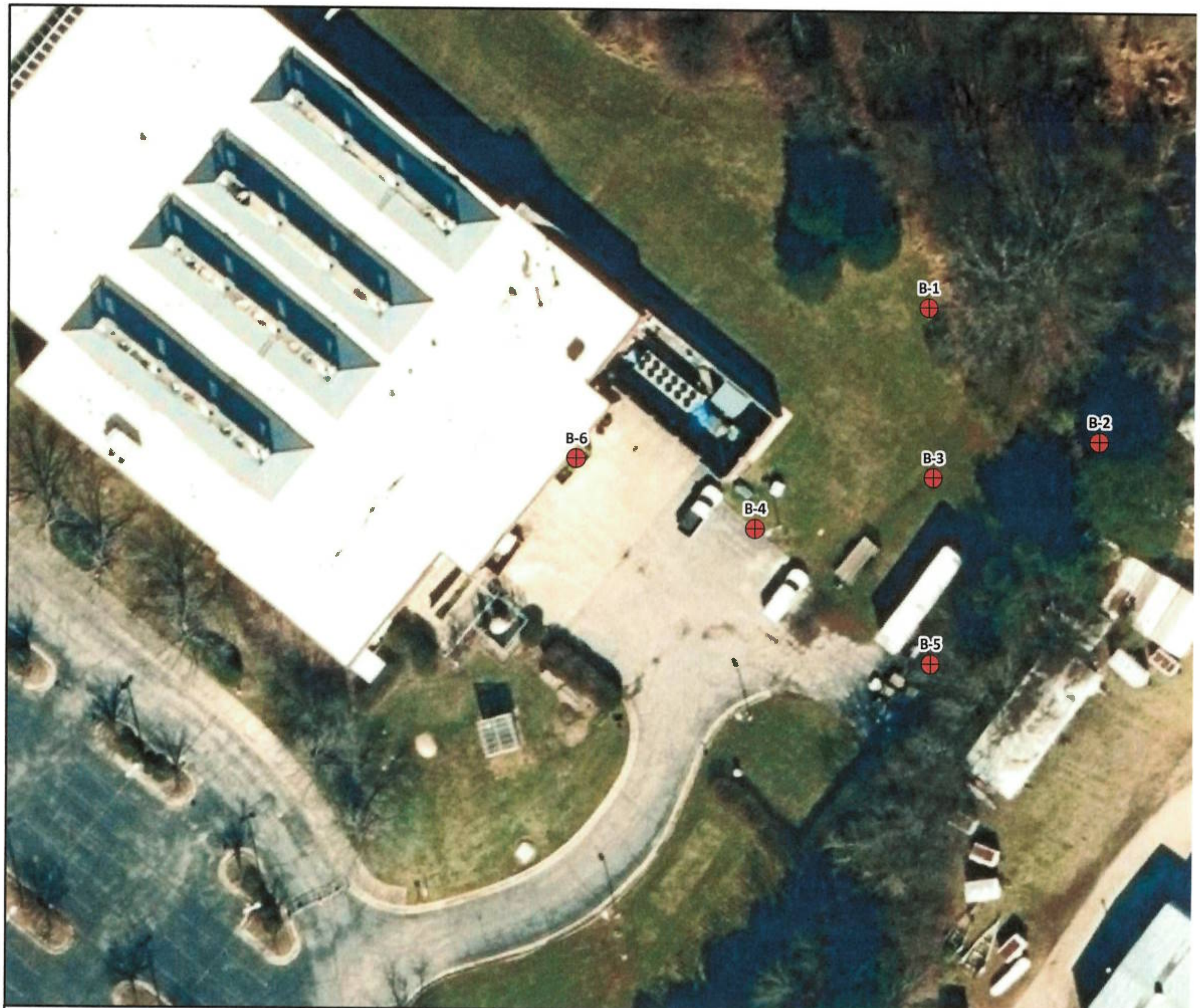
0 150 300 600 900 1,200 Feet

FROEHLING & ROBERTSON
*Engineering Stability Since 1881*

310 Hubert Street
Raleigh, North Carolina 27603
T 919.828.3441

| | |
|---|---|
| Client: | Dewberry |
| Project: | NCDA&CS Eaddy Building Addition |
| Location | Raleigh, Wake County, NC |
| Project Number: | 66A-0194 |
| Data: | Open Street |
| Date: | February 2023 |
| Scale: | 1 inch = 600 feet |

FIGURE No.: 1



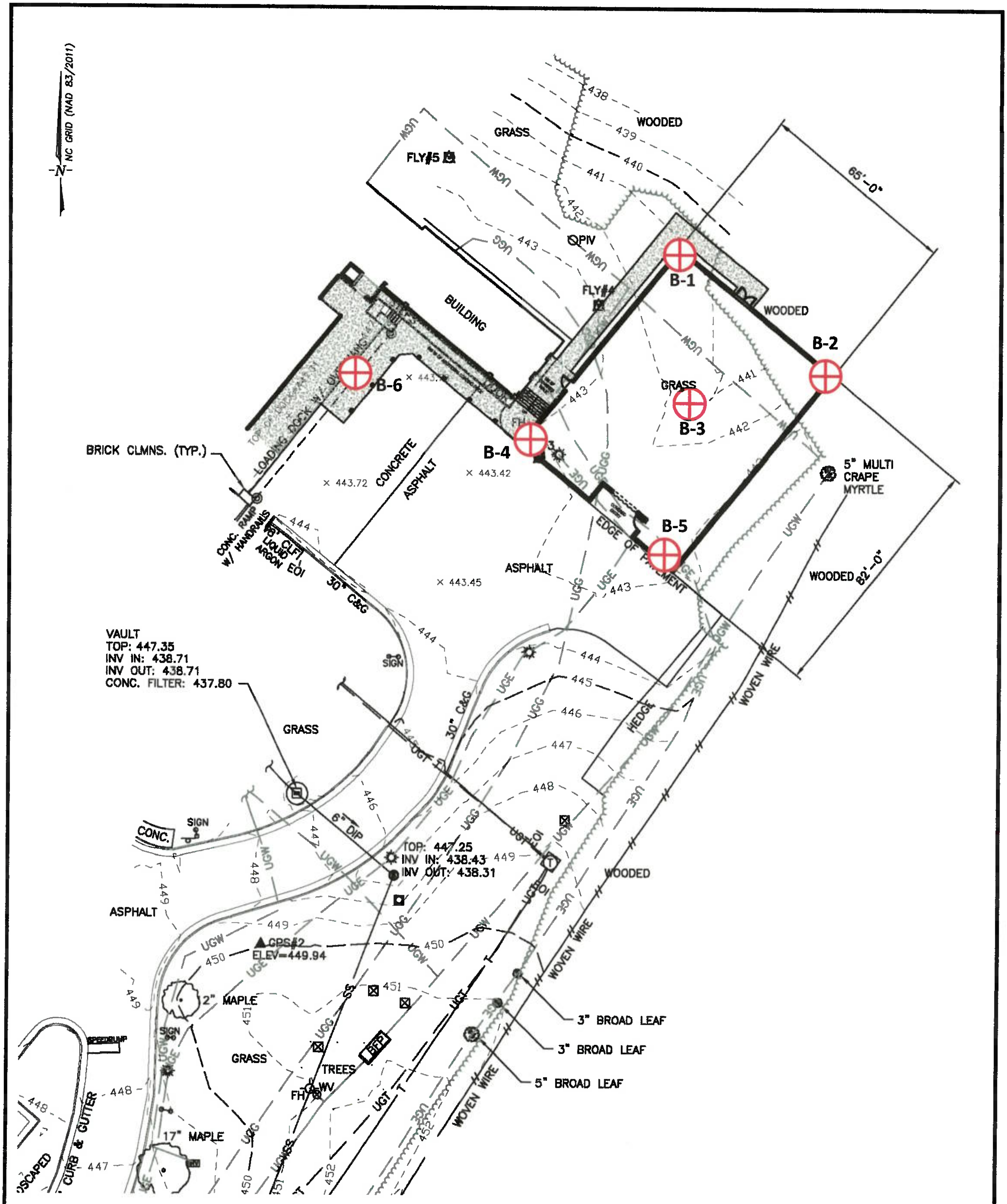

# Boring Location Plan

0 12.5 25 50

FROEHLING & ROBERTSON
*Engineering Stability Since 1881*

310 Hubert Street
Raleigh, North Carolina 27603
T 919.828.3441

| | | |
|---|---|---|
| Client: | Dewberry | |
| Project: | NCDA&CS Eaddy Building Addition | |
| Location | Raleigh, Wake County, NC | |
| Project Number: | 66A-0194 | |
| Data: | NCOne Map Parcel 2022/ Aerial 2021 | |
| Date: | February 2023 | Scale: 1 inch = 50 fe |




## BORING LOCATION PLAN


Froehling & Robertson, Inc.
306 Hubert Street
Raleigh, North Carolina 27603
T 919.828.3441


| | |
|---|---|
| Client: | Dewberry |
| Project: | NCDA&CS Eaddy Building Addition |
| Location: | Raleigh, Wake County, NC |
| Project Number: | 66A-0194 |
| Data Source: | Client Provided Plan |
| Date: | February 2023 |
| Scale: | Not to Scale |
| FIGURE No.: | 2A |

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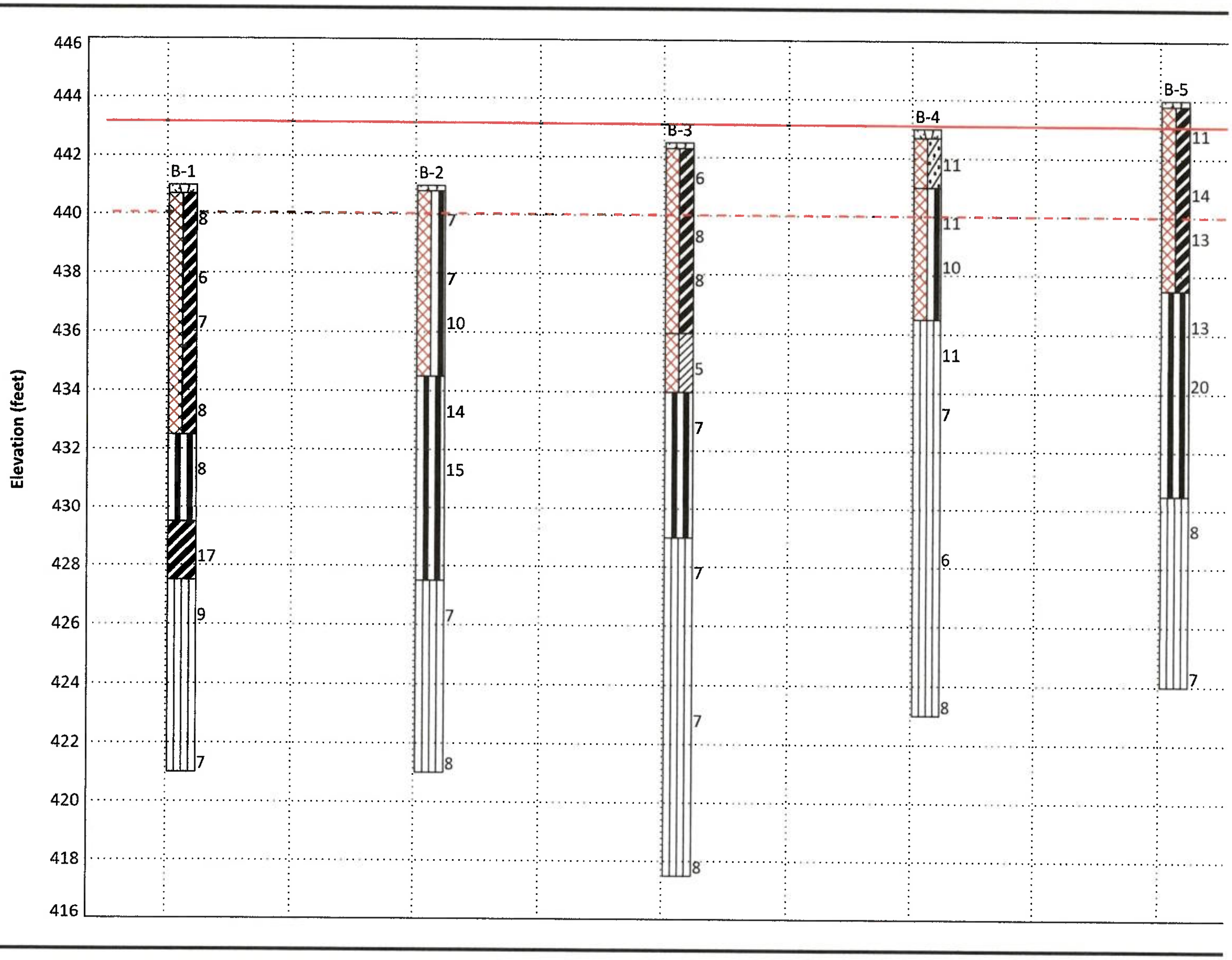
S

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

—— Finished Floor Elevati
- - - - Assumed Finished Be




ELEV_LANDSCAPE_8.5X11 66A-0194 BORING LOGS.GPJ F&R.GDT 1/30/23

# APPENDIX II

# BORING LOGS

**Table of Boring Coordinates**
**Dewberry-NCDA&CS Eaddy Building Addition**
**F&R Project No. 66A-0194**

| Boring | Northing (Y) | Easting (X) |
|---|---|---|
| B-1 | 751422 | 2085908 |
| B-2 | 751378 | 2085966 |
| B-3 | 751365 | 2085910 |
| B-4 | 751348 | 2085850 |
| B-5 | 751304 | 2085910 |
| B-6 | 751371 | 2085790 |

# KEY TO SOIL CLASSIFICATION

## Correlation of Penetration Resistance with Relative Density and Consistency

### Sands and Gravels

| No. of Blows, N | Relative Density |
|---|---|
| 0 - 4 | Very loose |
| 5 - 10 | Loose |
| 11 - 30 | Medium dense |
| 31 - 50 | Dense |
| Over 50 | Very dense |

### Silts and Clays

| No. of Blows, N | Relative Density |
|---|---|
| 0 - 2 | Very soft |
| 3 - 4 | Soft |
| 5 - 8 | Firm |
| 9 - 15 | Stiff |
| 16 - 30 | Very stiff |
| 31 - 50 | Hard |
| Over 50 | Very hard |

## Particle Size Identification (Unified Classification System)

| | |
|---|---|
| Boulders: | Diameter exceeds 8 inches |
| Cobbles: | 3 to 8 inches diameter |
| Gravel: | **Coarse** - 3/4 to 3 inches diameter<br>**Fine** - 4.76 mm to 3/4 inch diameter |
| Sand: | **Coarse** - 2.0 mm to 4.76 mm diameter<br>**Medium** - 0.42 mm to 2.0 mm diameter<br>**Fine** - 0.074 mm to 0.42 mm diameter |
| Silt and Clay: | Less than 0.07 mm (particles cannot be seen with naked eye) |

## Modifiers

The modifiers provide our estimate of the amount of silt, clay or sand size particles in the soil sample.

| Approximate Content | Modifiers |
|---|---|
| ≤ 5%: | Trace |
| 5% to 12%: | Slightly silty, slightly clayey, slightly sandy |
| 12% to 30%: | Silty, clayey, sandy |
| 30% to 50%: | Very silty, very clayey, very sandy |

| | Field Moisture Description |
|---|---|
| Saturated: | Usually liquid; very wet, usually from below the groundwater table |
| Wet: | Semisolid; requires drying to attain optimum moisture |
| Moist: | Solid; at or near optimum moisture |
| Dry: | Requires additional water to attain optimum moisture |

## Ground Water

$\nabla$ Water Level in Bore Hole Immediately after Drilling

$\blacktriangledown$ Static Water Level after 24 Hours

## UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

| MAJOR DIVISION | | | | | TYPICAL NAMES |
|---|---|---|---|---|---|
| | GRAVELS<br>More than 50% of coarse fraction larger than No. 4 sieve | CLEAN GRAVEL<br>(little or no fines) | | GW | Well graded gravels |
| | | | | GP | Poorly graded gravels |
| | | GRAVELS<br>with fines | | GM | Silty gravels |
| | | | | GC | Clayey gravels |
| | SANDS<br>More than 50% of coarse fraction smaller than No. 4 sieve | CLEAN SAND<br>(little or no fines) | | SW | Well graded sands |
| | | | | SP | Poorly graded sands |
| | | SAND<br>with fines | | SM | Silty sands, sand/silt mixtures |
| | | | | SC | Clayey sands, sand/clay mixtures |
| | SILTS AND CLAYS<br>Liquid Limit is less than 50 | | | ML | Inorganic silts, sandy and clayey silts with slightly plasticity |
| | | | | CL | Sandy or silty clays of low to medium plasticity |
| | | | | OL | Organic silts of low plasticity |
| | SILTS AND CLAYS<br>Liquid Limit is greater than 50 | | | MH | Inorganic silts, sandy micaceous or clayey elastic silts |
| | | | | CH | Inorganic clays of high plasticity, fat clays |
| | | | | OH | Organic clays of medium to high plasticity |
| HIGHLY ORGANIC SOILS | | | | PT | Peat and other highly organic soils |
| MISCELLANEOUS MATERIALS | | | | | PWR (Partially Weathered Rock) |
| | | | | | Rock |
| | | | | | Asphalt |
| | | | | | ABC Stone |
| | | | | | Concrete |
| | | | | | Surficial Organic Soil |

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# BORING LOG

**Boring:** B-1 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 441 ±
**Total Depth:** 20.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 440.7 | 0.3 | SURFICIAL ORGANIC SOILS | 1-4-4 | 0.0 | 8 | GROUNDWATER DATA: 0 Hr: Dry inside PVC 24 Hrs: Dry inside PVC |
| | | FILL: Firm, Orangish Brown and Brown, Moist, Silty Fine to Coarse Sandy CLAY (CH), with Trace Fine Gravel, Roots, and Mica | | 1.5 | | |
| | | | 2-3-3 | 2.0 | 6 | |
| | | | 2-3-4 | 3.5 | 7 | |
| | | | | 5.0 | | |
| | | Possible Surficial Organic Soil (6.5'-8.0') | 3-3-5 | 6.5 | 8 | |
| | | | | 8.0 | | |
| 432.5 | 8.5 | RESIDUAL: Firm, Orangish Brown, Moist, Clayey Fine Sandy SILT (MH), with Trace Roots | 3-4-4 | 8.5 | 8 | |
| | | | | 10.0 | | |
| 429.5 | 11.5 | Very Stiff, Reddish Brown, Moist, Fine to Medium Sandy Silty CLAY (CH), with Trace Mica | 4-7-10 | 11.5 | 17 | |
| | | | | 13.0 | | |
| 427.5 | 13.5 | Firm to Stiff, Yellow, Reddish Tan, and Red, Moist, Micaceous, Clayey Fine Sandy SILT (ML) | 6-5-4 | 13.5 | 9 | |
| | | | | 15.0 | | |
| | | | 2-3-4 | 18.5 | 7 | |
| 421.0 | 20.0 | Boring Terminated at 20.0 feet. | | 20.0 | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

BORING LOG 66A-0194 BORING LOGS.GPJ F&R.GDT 1/30/23

Froehling & Robertson, Inc.

# BORING LOG

**Boring:** B-2 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 441 ±
**Total Depth:** 20.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 440.8 | 0.2 | SURFICIAL ORGANIC SOILS | 3-4-3 | 0.0 – 1.5 | 7 | GROUNDWATER DATA:<br>0 Hr: Dry, Caved at 17.7'<br>24 Hrs: Dry, Caved at 18.3' |
| | | FILL: Firm to Stiff, Red, Orange, and Brown, Moist, Clayey Fine to Coarse Very Sandy SILT (MH), with Trace Roots, Mica (3.5'-5.0'), and Fine Gravel<br>1/8" Diameter Roots (0.2'-1.5') | 3-3-4 | 2.0 – 3.5 | 7 | |
| | | | 3-3-7 | 3.5 – 5.0 | 10 | |
| 434.5 | 6.5 | RESIDUAL: Stiff, Reddish Brown, Moist, Micaceous, Fine to Coarse Sandy Clayey SILT (MH), with Trace Fine to Coarse Rock Fragments (8.5-13.5) | 4-6-8 | 6.5 – 8.0 | 14 | |
| | | | 5-7-8 | 8.5 – 10.0 | 15 | |
| 427.5 | 13.5 | Firm, Tan and Maroon, Moist to Wet, Micaceous, Fine Very Sandy SILT (ML) | 3-3-4 | 13.5 – 15.0 | 7 | |
| | | Wet (18.5'-20.0') | 3-3-5 | 18.5 – 20.0 | 8 | |
| 421.0 | 20.0 | Boring Terminated at 20.0 feet. | | | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

Froehling & Robertson, Inc.

# BORING LOG

**Boring:** B-3 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 442.5 ±
**Total Depth:** 25.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 442.3 | 0.2 | SURFICIAL ORGANIC SOILS | 1-3-3 | 0.0 - 1.5 | 6 | GROUNDWATER DATA: 0 Hr: Dry, Caved at 22.9' 24 Hrs: Dry, Caved at 23.3' |
| | | FILL: Firm, Red, Orange, and Brown, Moist, Fine to Coarse Sandy Very Silty CLAY (CH), with Trace Fine Gravel, Mica, and Fine Roots | 3-4-4 | 2.0 - 3.5 | 8 | |
| | | | 4-4-4 | 3.5 - 5.0 | 8 | |
| 436.0 | 6.5 | POSSIBLE FILL: Firm, Brown and Tan, Wet, Silty Fine Sandy CLAY (CL), with Trace Roots | 3-2-3 | 6.5 - 8.0 | 5 | |
| 434.0 | 8.5 | RESIDUAL: Firm, Reddish Brown, Wet, Fine Slightly Sandy Clayey SILT (MH), with Trace Roots and Mica | 2-3-4 | 8.5 - 10.0 | 7 | |
| 429.0 | 13.5 | Firm, Reddish Tan, Wet, Micaceous, Fine Sandy SILT (ML) | 2-3-4 | 13.5 - 15.0 | 7 | |
| | | | 3-3-4 | 18.5 - 20.0 | 7 | |
| | | | 3-3-5 | 23.5 - 25.0 | 8 | |
| 417.5 | 25.0 | Boring Terminated at 25.0 feet. | | | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

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# BORING LOG

**Boring:** B-4 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 443 ±
**Total Depth:** 20.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 442.7 | 0.3 | SURFICIAL ORGANIC SOILS | 4-7-4 | 0.0 | 11 | GROUNDWATER DATA:<br>0 Hr: Dry, Caved at 17.8'<br>24 Hrs: Dry, Caved at 18.0' |
| | | FILL: Medium Dense, Red, Orange, and Tan, Moist, Silty Clayey Fine to Coarse SAND (SC), with Fine to Coarse Gravel | | 1.5 | | |
| 441.0 | 2.0 | Stiff, Red, Orange, and Brown, Moist, Fine to Coarse Slightly Sandy Clayey SILT (MH), with Trace Fine to Coarse Gravel | 4-5-6 | 2.0 | 11 | |
| | | | | 3.5 | | |
| | | | 3-4-6 | 3.5 | 10 | |
| | | | | 5.0 | | |
| 436.5 | 6.5 | RESIDUAL: Firm, Orange, Tan, and Maroon, Moist, Micaceous, Clayey Fine Sandy SILT (ML) | 5-5-6 | 6.5 | 11 | |
| | | | | 8.0 | | |
| | | | 3-3-4 | 8.5 | 7 | |
| | | | | 10.0 | | |
| | | | 2-3-3 | 13.5 | 6 | |
| | | | | 15.0 | | |
| | | | 3-3-5 | 18.5 | 8 | |
| 423.0 | 20.0 | Boring Terminated at 20.0 feet. | | 20.0 | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

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# BORING LOG

**Boring:** B-5 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 444 ±
**Total Depth:** 20.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 443.8 | 0.2 | SURFICIAL ORGANIC SOILS | 2-5-6 | 0.0 - 1.5 | 11 | GROUNDWATER DATA:<br>0 Hr: Dry inside PVC<br>24 Hrs: Dry inside PVC |
| | | FILL: Stiff, Reddish Brown, Moist, Fine to Coarse Slightly Sandy Silty CLAY (CH), with Trace Fine to Coarse Gravel, Mica, and Roots | 5-6-8 | 2.0 - 3.5 | 14 | |
| | | | 4-5-8 | 3.5 - 5.0 | 13 | |
| 437.5 | 6.5 | RESIDUAL: Stiff to Very Stiff, Reddish Brown, Moist, Fine to Coarse Slightly Sandy Clayey SILT (MH), with Trace Roots (6.5'-8.0'), Fine to Coarse Rock Fragments, and Mica | 3-5-8 | 6.5 - 8.0 | 13 | |
| | | | 6-8-12 | 8.5 - 10.0 | 20 | |
| 430.5 | 13.5 | Firm, Reddish Tan, Moist, Micaceous, Fine Sandy SILT (ML) | 3-4-4 | 13.5 - 15.0 | 8 | |
| | | | 3-3-4 | 18.5 - 20.0 | 7 | |
| 424.0 | 20.0 | Boring Terminated at 20.0 feet. | | | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

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# BORING LOG

**Boring:** B-6 (1 of 1)

**Project No:** 66A-0194
**Client:** Dewberry Engineers, Inc.
**Project:** NCDA&CS Eaddy Building Addition
**City/State:** Raleigh, NC

**Elevation:** 443.5 ±
**Total Depth:** 10.0'
**Boring Location:** See Boring Location Plan

**Drilling Method:** 2.25" ID HSA
**Hammer Type:** Automatic
**Date Drilled:** 1/6/23
**Driller:** S. Davis

| Elevation | Depth | Description of Materials (Classification) | * Sample Blows | Sample Depth (feet) | N-Value (blows/ft) | Remarks |
|---|---|---|---|---|---|---|
| 442.9 | 0.6 | CONCRETE | | | | GROUNDWATER DATA:<br>0 Hr: Dry, Caved at 7.7'<br>24 Hrs: Dry, Caved at 7.8' |
| 442.6 | 0.9 | ABC STONE | 4-3-4 | 0.7 | 7 | |
| 441.5 | 2.0 | FILL: Firm, Red and Orange, Moist, Fine to Coarse Slightly Sandy Silty CLAY (CH), with Trace Mica and Fine Gravel | 3-4-4 | 2.1 / 2.2 | 8 | |
| | | RESIDUAL: Firm to Very Stiff, Orange and Tan, Moist, Micaceous, Fine Sandy SILT (ML) | 3-3-4 | 3.6 | 7 | |
| | | | | 5.1 | | |
| | | | 3-4-4 | 6.5 | 8 | |
| | | | | 8.0 | | |
| | | | 7-9-7 | 8.5 | 16 | |
| 433.5 | 10.0 | Boring Terminated at 10.0 feet. | | 10.0 | | |

*Number of blows required for a 140 lb hammer dropping 30" to drive 2" O.D., 1.375" I.D. sampler a total of 18 inches in three 6" increments. The sum of the second and third increments of penetration is termed the standard penetration resistance, N-Value.

# APPENDIX III

# LABORATORY TEST RESULTS

FROEHLING & ROBERTSON

*Engineering Stability Since 1881*

# ATTERBERG LIMITS

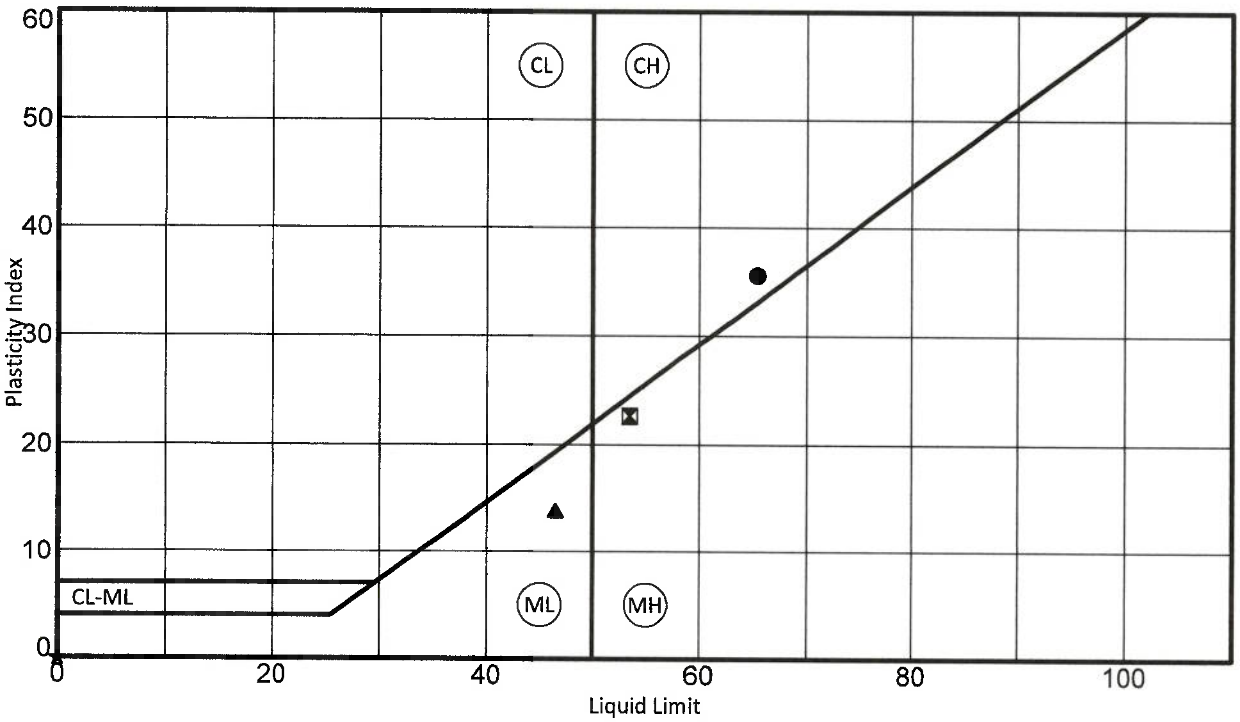
**Sheet:** 1 of 1

**Project No:** 66A-0194

**Client:** Dewberry

**Project:** NCDA&CS Eaddy Building Addition

**City/State:** Raleigh, NC




| Boring No. | Location | Depth | LL | PL | PI | Fines | Classification | % Natural Water Content |
|---|---|---|---|---|---|---|---|---|
| ● B-1 | S-6 | 11.5' - 13.0' | 65 | 30 | 35 | 69.2 | SANDY FAT CLAY (CH) | 22.4 |
| ⊠ B-2 | S-5 | 8.5' - 10.0' | 53 | 31 | 22 | 53.1 | SANDY ELASTIC SILT (MH) | 18.5 |
| ▲ B-4 | S-4 | 6.5' - 8.0 | 46 | 33 | 13 | 74.5 | SILT with SAND (ML) | 23.9 |
| ★ B-6 | S-2 | 2.1' - 3.5' | NP | NP | NP | 79.4 | SILT with SAND (ML) | 20.9 |

ATTERBERG_LIMITS_USCS_W/_LOCATION 66A-0194 LAB TESTING.GPJ F&R.GDT 1/25/23

# APPENDIX IV

# GBA DOCUMENT

# Important Information about This

# Geotechnical-Engineering Report

**Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.**

**While you cannot eliminate all such risks, you can manage them. The following information is provided to help.**

**The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.**

## Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled.* No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

## Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety.* Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

## You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

## This Report May Not Be Reliable

*Do not rely on this report* if your geotechnical engineer prepared it:

- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

## Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.

### This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, *they are not final*, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

### This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

- confer with other design-team members,
- help develop specifications,
- review pertinent elements of other design professionals' plans and specifications, and
- be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

### Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for informational purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

### Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

### Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

### Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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